This is a digital copy of a book that was preserved for generations on library shelves before it was carefully scanned by Google as part of a project to make the world's books discoverable online.

It has survived long enough for the copyright to expire and the book to enter the public domain. A public domain book is one that was never subject to copyright or whose legal copyright term has expired. Whether a book is in the public domain may vary country to country. Public domain books are our gateways to the past, representing a wealth of history, culture and knowledge that's often difficult to discover.

Marks, notations and other marginalia present in the original volume will appear in this file - a reminder of this book's long journey from the publisher to a library and finally to you.

Usage guidelines

Google is proud to partner with libraries to digitize public domain materials and make them widely accessible. Public domain books belong to the public and we are merely their custodians. Nevertheless, this work is expensive, so in order to keep providing this resource, we have taken steps to prevent abuse by commercial parties, including placing technical restrictions on automated querying.

We also ask that you:

+ *Make non-commercial use of the files* We designed Google Book Search for use by individuals, and we request that you use these files for personal, non-commercial purposes.

+ *Refrain from automated querying* Do not send automated queries of any sort to Google's system: If you are conducting research on machine translation, optical character recognition or other areas where access to a large amount of text is helpful, please contact us. We encourage the use of public domain materials for these purposes and may be able to help.

+ *Maintain attribution* The Google "watermark" you see on each file is essential for informing people about this project and helping them find additional materials through Google Book Search. Please do not remove it.

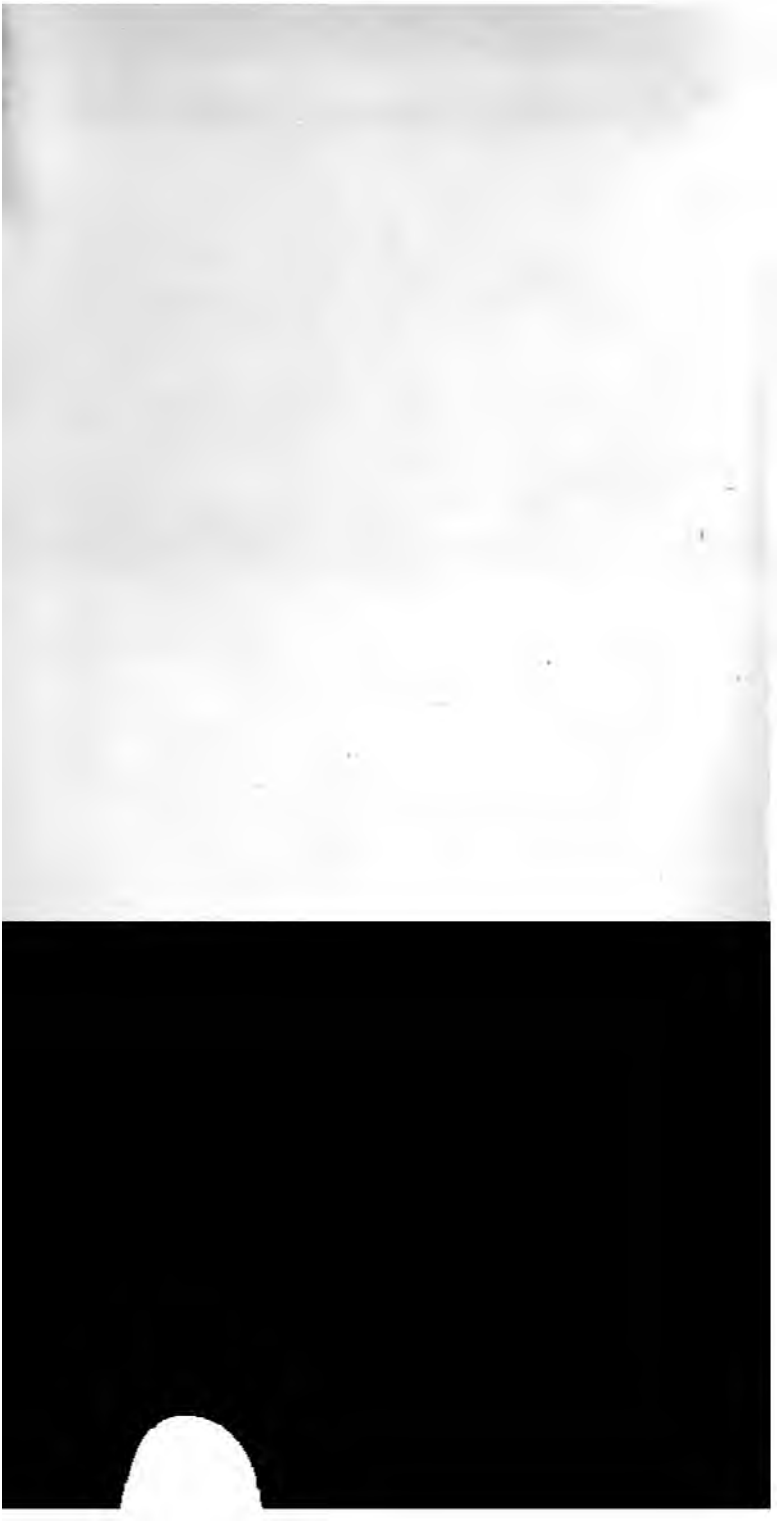
+ *Keep it legal* Whatever your use, remember that you are responsible for ensuring that what you are doing is legal. Do not assume that just because we believe a book is in the public domain for users in the United States, that the work is also in the public domain for users in other countries. Whether a book is still in copyright varies from country to country, and we can't offer guidance on whether any specific use of any specific book is allowed. Please do not assume that a book's appearance in Google Book Search means it can be used in any manner anywhere in the world. Copyright infringement liability can be quite severe.

About Google Book Search

Google's mission is to organize the world's information and to make it universally accessible and useful. Google Book Search helps readers discover the world's books while helping authors and publishers reach new audiences. You can search through the full text of this book on the web at `http://books.google.com/`

LELAND·STANFORD·JVNIOR·VNIVERSITY

5/U.D
R887



PROCEEDINGS

OF THE

ROYAL PHYSICAL SOCIET

OF

EDINBURGH.

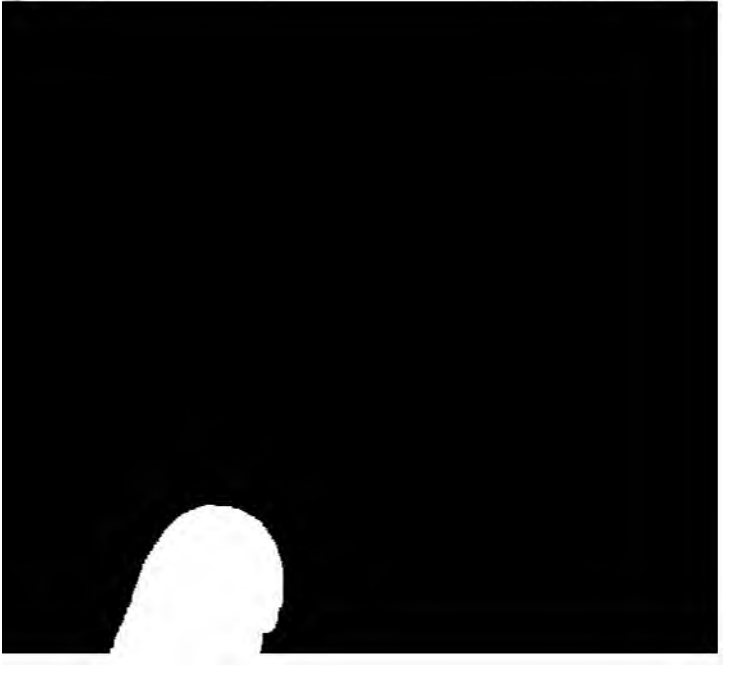
VOL. IX.

1885-88.

EDINBURGH:
PRINTED FOR THE SOCIETY, AND PUBLISHED AT
THEIR ROOMS, 18 GEORGE STREET.
MDCCCLXXXVIII

STANFORD LIBI

265833



ROYAL PHYSICAL SOCIETY.

Instituted 1771. *Incorporated by Royal Charter* 1778.

Office-Bearers 1889.

PRESIDENT.

Ramsay H. Traquair, M.D., F.R.S.

VICE-PRESIDENTS.

Professor James Geikie, LL.D., F.R.S.
G. Sims Woodhead, M.D., F.R.S.E.
George Brook, F.L.S., F.R.S.E.

SECRETARY.

William Evans, F.F.A., F.R.S.E.

ASSISTANT-SECRETARY.

John Gunn, F.R.S.G.S.

TREASURER.

George Lisle, C.A., F.F.A.

LIBRARIAN.

William Russell, M.D., F.R.C.P.E.

COUNCILLORS.

Johnson Symington, M.D., F.R.S.E.
John Falconer King, F.C.S.
J. A. Harvie-Brown, F.R.S.E.
G. Lovell Gulland, M.A., M.B.
R. Kidston, F.R.S.E., F.G.S.
T. B. Sprague, M.A., F.R.S.E.
T. Wemyss Fulton, M.B., C.M.
J. Gibson, Ph.D., F.R.S.E.
David Hepburn, M.B.
A. B. Herbert.
Rev. A. B. Morris.
Professor Sir William Turner, LL.D., F.R.S.

PROCEEDINGS

OF THE

ROYAL PHYSICAL SOCIETY.

SESSION CXV.

Wednesday, 18th November 1885.—BENJAMIN N. PEACH, Esq., F.R.S.E., F.G.S., President, in the Chair.

The CHAIRMAN delivered the following opening address:

In opening the 115th session of the Royal Physical Society, it is gratifying to be able to point to its continued prosperity, so clearly manifested by an increasing membership, by the energy displayed by the various office-bearers, and in particular by the number of valuable papers contributed to the new part of the *Proceedings*. The last instalment of the publications of the Society, containing an address by Dr Traquair on "Biological Nomenclature" and twenty-five original papers, may be compared favourably with its predecessors in regard to the importance of the work achieved by the Fellows. Such a record shows how various members continue to prosecute their researches in different departments of science with a success which augurs well for the future. I desire, now, to express my gratitude for the honour you conferred on me by appointing me to the presidentship, and for the cordial support I received from the Fellows while performing the duties of the office. It has been a source of pleasure to me to further the interests of this Society so far as it lay within my power, and I need hardly add that its future success will always be dear to me.

The special subject to which I wish to direct your attention this evening is one of great interest and importance to geologists—viz., the light shed by organic remains on the history of the strata in which they are embedded. For the elucidation of this subject I propose to select several illustrations from the geology of Scotland with which I am familiar.

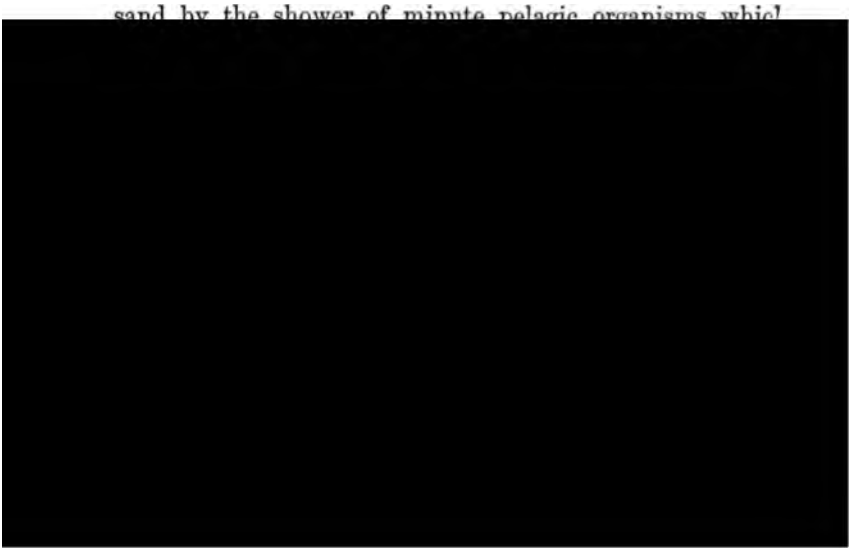
For the last few years I have been engaged in the study of the Silurian rocks of the North-west Highlands, so closely linked with the famous controversy of the age of the crystalline schists of the Highlands. As these are the oldest strata from which fossils have been obtained in Scotland, it may not be inappropriate to place them in the foreground. The basement beds of the Silurian rocks of Sutherland and Ross consist of coarse-grained, false-bedded grits or quartzite resting on a remarkably even plane of marine denudati carved out of Archaean gneiss and the overlying Cambri conglomerates and sandstones. There is therefore a mark unconformability between the Silurian strata on the hand and the Archaean and Cambrian rocks on the ot No organic remains have yet been detected in this lo division of the quartzite series, which attains a thickne about 200 feet. Overlying this subdivision we find a 300 feet of comparatively fine-grained quartzites, which, certain exceptions, are characterised by much more re bedding. Almost every bed is pierced by a series of ve cylinders or "pipes," varying in diameter from $\frac{1}{8}$ to 3 inches, not distributed equally throughout the grou arranged in definite order—each variety being confi certain bands. As a rule, these cylinders become numerous towards the top of the quartzite series. Th be no doubt whatever that the "pipes" are due to t solidated casts of burrowing annelides. Next in o find the "Fucoid beds," about 50 feet of grey shal with lenticular masses of dolomitic limestone and o flaggy grits—the whole series weathering with ochreous tint from the presence of ferruginous mat shales are traversed along the bedding planes by worm casts, which have been mistaken for fu hence the name that has been misapplied to t

When a shale bed overlies a sandy one, the cast brought up from the underlying layer by the burrowing worm is still a cylinder of hardened sand, and not the flattened plant-like impression produced by the cast formed out of the softer ooze of the shale bed itself. To the foregoing group succeeds a massive bed of calcareous grit or quartzite upwards of 30 feet thick, pierced by vertical worm pipes, and also containing, along certain bedding planes, the remains of small tubicolar annelides *(Serpulites Maccullochii)*. Specimens of Orthoceratites have also been obtained from this bed—one by a brother of Mr Clark of Eribol, and another by Professor Lapworth.

The Silurian strata just described are overlain by a vast mass of limestone divisible into several well-marked zones, lithologically distinct. One feature, however, is common to the whole series—that nearly every bed is more or less traversed by worm casts; indeed, some of the bands consist almost wholly of these casts with a matrix just sufficient to hold them together. The rough exterior so characteristic of some of the limestones is partly due to this cause and partly to the fact that the matrix has crystallised in a different manner from the casts, which makes it more easily eroded by denuding agencies. The lowest beds of limestone are sandy and shaly, and contain two zones of serpulites, the highest being about 30 feet from the base. In the overlying 300 feet of limestone no fossils have yet been obtained in the Durness area, but the late Mr C. W. Peach found an Orthoceras at Inchnadamff which must have come from this horizon. Higher up in the series there are several fossiliferous zones yielding an abundant suite of fossils, comprising *Maclurea*, *Ophileta*, *Murchisonia*, *Pleurotomaria*, Orthoceratites, Lamellibranchs, Brachiopods, and Trilobites—an assemblage of fossils identical with that obtained by the Geological Survey of Canada from the lowest Silurian and uppermost Cambrian strata of Canada and the eastern part of the United States. Indeed, many of the forms are common to the two areas. In the North-west Highlands we do not find any beds succeeding in natural order to the limestone; in fact, there is now only a remnant of what originally was a more extensive and in all likelihood a much thicker formation. The highest

limestone zones are preserved only at Durness; elsewhere, along the line extending from Eribol to Sleat, in Skye, the limestones occur in lenticular masses, which are not due to original irregularity of deposit, but to earth movements which gave rise to reversed faults at low angles to the horizon. By this means the underlying gneiss and Cambrian rocks are driven over the Silurian strata for great distances. In those portions of the Silurian series which were not displaced, as well as in those which were driven horizontally forward, there is a striking regularity in the order of succession. All the zones already mentioned, including minor subdivisions not exceeding a few inches in thickness, are traceable over the whole area for a distance of ninety miles from north to south.

What, then, are the inferences that may naturally be deduced from a consideration of these data? In the case of the basal quartzites, where we have a passage from a land surface to a sea bed, there is little or no organic matter mixed with the coarse siliceous sand, which, from its coarse texture and the false bedding of the layers, bears evidence o rapid accumulation. There would therefore be no food f the support of annelides under these conditions. But w the slower accumulation of sediment indicated by the "pi rock," there was evidently time for the fertilisation of sand by the shower of minute pelagic organisms whic



misled the older observers, and made them regard these casts as the remains of seaweeds. Similar phenomena have been met with in strata of the same general age in America, where they have been usually attributed to the remains of plants, each variety being designated by a different name. Were we to proceed on this principle with the worm casts of the Durness rocks, a lengthy treatise might be devoted to the description of the various forms which they assume. Had the matrix of the limestone been more favourable for preserving small organisms, I have no doubt we should have been able to obtain as rich a variety of annelide jaws from the Durness strata as Mr Hinde procured from the nearly unaltered Silurian beds of Gothland.

The zone of serpulite grit overlying the fucoid beds points to a shallowing of the area of deposit, and the introduction of coarser sediment, thus indicating oscillations in the downward movements, though on the whole they resulted in subsidence. After the deposition of the serpulite grit, hardly any sediment derived from the land entered into the composition of the overlying limestones. For a short time there was a slight admixture of sand and mud with the calcareous matter; but eventually nothing seems to have fallen on the sea-floor but the remains of minute organisms, whose calcareous and siliceous skeletons have slowly built up the great mass of limestone and chert so conspicuously developed at Durness. That small pelagic animals played the chief part in the formation of this accumulation of limestone is rendered almost certain by the fact that most of the beds are traversed by worm casts in such a manner, that nearly every particle must have passed through the intestines of worms. It is evident that the limestones cannot be due to coral reefs, for if such had been the case, the corals must have been comminuted as fast as they grew. Only one undoubted specimen of coral resembling a *Michelinea*, embedded in a fine calcareous sediment, has been obtained from the series. That shell banks had little to do with the accumulation of the limestone is apparent from the mode of occurrence of the shells which are found in it. The most abundant forms are chambered shells, such as Orthoceratites, Lituites, and

Nautilus; next in order are the Gasteropods, chiefly Maclureas, Pleurotomarias, etc.; while the lamellibranchs and brachiopods rank last in point of number. The two latter are found with their valves attached, and the lamellibranchs are found in the position in which they lived and died. All the specimens show that every open space into which the mud could gain access and the worms could crawl are traversed by worm casts. In the case of the orthoceratites, they seem to have lain long enough uncovered by sediment to allow the septa to be dissolved away from the siphuncles which they held in place. Many of those siphuncles are now found isolated; indeed, Salter founded his genus *Piloceras* on such large examples as those found in *Endoceras*. Sponges of the genus *Archæocyathus* and *Calathium* occur at intervals in the muddy matrix. One example is preserved in chert; but the larger masses of che in the limestone do not seem to be derived from sponges, more probably from the siliceous skeletons of diatoms, wh in all likelihood, were as abundant in that ancient ocea they are now. No undoubted remains of foraminifera h been discovered, though on several horizons there are z of limestone made up of small rounded bodies, prob oolites; but owing to the fact that the limestones are cry line, and that many of them have been more or less do tised, it is now almost impossible to decide definitely the nature of these spherules. For these reasons it is less to find minute organisms in this formation. The substance of the larger fossils has in almost every cas dissolved out, and the spaces have been filled with c and in some cases with Beekite, so that all the finer ma on their surfaces are obliterated.

In view of the foregoing evidence, it is clear t physical conditions which prevailed during the dep the Silurian strata in the north-west Highlands m been remarkably uniform. As already indicated, t are of an American type, and do not resemble the in the contemporaneous deposits of Wales and Indeed, so far as the order of succession of the their fossil contents are concerned, we have an al

counterpart of the strata exposed along the axis of older Palæozoic rocks, stretching from Canada through the eastern States of North America. In the latter region, the Silurian strata of Sutherlandshire are represented by—(1.) the Potsdam Sandstone, always described as being vertically piped by *Scolithus*, like the "pipe-rock;" (2.) the Calciferous group; and (3.) part of the Trenton Limestone. Now, it might be contended that this remarkable identity in the order of succession of the beds and fossil contents in these two widely-separated areas points to contemporaneous deposition; and on the other hand it might be argued with greater probability that the beds are homotaxial, or in other words that the same relative succession of events prevailed in the two areas, though not at the same time. Whichever view is adopted, I think that there can be little doubt that some old shore-line or shallow sea must have stretched across the North Atlantic or Arctic Oceans, along which the forms migrated from one province to the other, and that some barrier must have cut off this area from that of Wales and Central Europe.

Another excellent illustration of the value of fossiliferous zones as an aid to the solution of the geological structure of a special region may be found in the Lower Silurian rocks of the Moffat district, in the south of Scotland. Throughout the Southern Uplands the lithological character of the Lower Silurian rocks are remarkably uniform, consisting mainly of greenish greywackes, grits, and shales, thrown into a series of parallel folds. The magnificent coast sections at St Abb's Head and in the south-west of Scotland show how the same beds are repeated by normal and inverted anticlines and synclines over wide areas. The difficulty of unravelling the geological structure of the southern uplands is further increased by the limited number of fossils obtained from the grits, greywackés, and shales. There are, however, certain bands of black shales charged with graptolites which have been of great service to the field geologist. The exhaustive researches of Professor Lapworth in the Moffat area have conclusively proved that, so far as that region is concerned, the black shales occur along the crests of anticlinal folds, the overlying grits and shales having been removed by denuda-

tion. He has further shown that the Moffat black shale series, varying from 300 to 500 feet in thickness, is divisible into several zones, each containing a distinct suite of graptolites. By means of these zones he has demonstrated that many of the anticlinal folds are inverted, so that what appears at first sight to be an ascending series is in reality deceptive. In the prosecution of the Geological Survey of that region I have had exceptional opportunities for examining the sections described by Professor Lapworth, and it gives me pleasure to express my appreciation of the accuracy of his observations and of the value of his researches. But when we pass beyond the limits of the Moffat district the classification of the black shales undergoes important modifications. It sometimes happens that certain graptolites, which, in the Moffat area, are confined to separate horizons, are found side by side in the same band. For example, near Castle-Douglas some of the fossils characteristic of the Glenkiln group in the Moffat region are associated with graptolites belonging to the horizon of the Hartfell beds, while in another direction the members of the Birkhill group disappear altogether, and are represented only by barren grey wackes and shales. Some forms, which he assumes to hav become extinct during the deposition of the Moffat group reappear in the greywackes overlying the black shales. Th assumption that the disappearance of a species from a pa ticular horizon implies its extinction, when it may be d merely to a change of conditions causing temporary mig tion, may be adduced as an instance of unsafe reasoning f purely negative evidence. Such an inference is never and is apt to lead to erroneous conclusions. Professor C pole, of the Pennsylvanian Geological Survey, has rece published parallel instances from the Devonian strata of United States, where *spirifers* occur in the same slab w were supposed to characterise separate zones of that f tion. He also shows that *Halycites catenularia*, whicl believed to be a characteristic fossil of the Niagara Lime and to have become extinct at the close of the depositi this zone, reappears in other limestones occupying a horizon. The case of *Dictyonema*, which was suppo

have disappeared in Cambrian or early Silurian time, but has now been proved to be a common Devonian fossil, forms another example of the danger of founding conclusions on purely negative evidence.

The passage beds between the Upper Silurian and Lower Old Red Sandstone formations in the south of Scotland present certain features of special interest to the palæontologist. The greatest development of Upper Silurian strata in Scotland extends along the border from the Cheviots to Burrow Head, but at present I propose to confine my attention to the exposures of these rocks in Lanarkshire and the Pentland Hills. In the area of Upper Silurian rocks at Lesmahagow, about 4000 feet of greywackes and shales are conformably overlain by a succession of red marls and conglomerates marking the lowest beds of the Old Red Sandstone. A similar passage is met with in the anticlinal axis of Upper Silurian rocks in the Hagshaw Hills, and also in the Pentland area. The highest Silurian strata in these separate areas consist of greenish and grey sandstones, shales, and greywackes, containing a peculiar assemblage of fossils. These beds are the great home of the Eurypterids. Indeed, the strata in the Lesmahagow area are widely known on account of the numerous species obtained from them, which have been described by Huxley, Salter, and Woodward. The passage beds from the Ludlow formation to the Hereford type of the Lower Old Red Sandstone in Shropshire have afforded numerous fragments of Eurypterids nearly allied to those of Lesmahagow, while the other included fossils closely resemble those from the same horizon in Scotland. Towards the top of the Upper Silurian formation in America, in the Water-lime group, Eurypterids are also abundant. Now, I venture to think that the occurrence of the Ludlow facies of fossils in these widely-separated areas does not point to contemporaneous deposition. In my opinion, this remarkable group of fossils represents the shallow-water and shore animals of the Silurian sea. Were older Silurian land surfaces and shore deposits to be found, they might be expected to yield a similar fauna, though the species would in all probability be distinct. The occurrence, therefore, of the

Ludlow type of fossils in any particular area serves to indicate that the upward movements which converted portions of the Silurian sea into a continental area with inland lakes had begun to manifest themselves, but such shore conditions may have been contemporaneous with marine conditions in other areas.

In support of the contention that the Ludlow facies of fossils indicates shore conditions, and, in particular, that the Eurypterids were shore animals, I may point to the fact that the oldest air-breathing arachnids have been obtained from beds containing these fossils. These are *Palæophoneus nuncius* from Gothland; another Palæophoneus from Lesmahagow; and a third scorpion has been described by Professor Whiteaves from the Water-lime group of America, long known as the deposit in which the *Eurypterus remipes* occurs. Though I have mentioned the Swedish specimen first because it was first described, I believe that the American specimen was first discovered, so that the latter country is justly entitled to the honour of priority of discovery. The presence of air-breathers in these strata points to proximity of land, and I have no doubt that our knowledge of the plants and land animals of that ancient period will yet be largely increased when the beds occupying this horizon are subjected to more minute examination. The occurrence of the peculiar phyllopods (*Ceratiocaris*) in such numbers in strata of this age has an important bearing on this question for all the recent forms are either fresh-water or confined inland seas and lakes. It is highly probable, therefore, th their representatives in Upper Silurian times may have be confined to shallow water along the margin of the Silur sea, or to estuaries.

The Lower Old Red Sandstone, as developed in Scot was deposited in a series of lakes or inland seas form the elevation of portions of the old Silurian sea-floor. conclusion is based partly on the character of the stra absence of undoubtedly marine fossils, and, in particu the peculiar facies of the fish fauna of the Moray Firt and of the Midland valley. The enormous thickness deposits in the central basin points to prolonged s

of the areas of deposit, while the Highland tableland either remained stationary or formed an axis of elevation. The great succession of conglomerates, sandstones, and shales, amounting to 20,000 feet in thickness, is composed more or less of the *débris* of the crystalline rocks of the Highlands; even the pebbles in the conglomerates of Uamh Var, which form the highest members of the Lower Old Red Sandstone of the Midland valley, have been derived from areas of crystalline rocks not far removed from the Highland barrier. The latter fact leads us to infer that portions of the old tableland still remained above water towards the close of the Lower Old Red Sandstone period. From an examination of the physical relations of the strata along the Highland border, it is manifest that there must have been irregular subsidence of the land along the northern margin of the midland basin. For example, on the shore at Stonehaven, nearly 5000 feet of sandstones, flags, and shales underlie the great volcanic series so splendidly developed in the Sidlaws and the Ochils. But when we pass to the south-west of the Stonehaven area into Forfarshire and Perthshire, this accumulation of sedimentary deposits is overlapped by the representatives of the volcanic series, till the latter rest directly on the ancient crystalline rocks. Although this vast thickness of strata accumulated in a lake, it is evident that the depth of water never could have been very great, for bands of conglomerate frequently occur in the order of succession, composed of river-borne pebbles. Most of these have been derived from the crystalline rocks of the Highlands, while not a few are composed of the same materials as the ejectamenta of the Lower Old Red Sandstone volcanoes, which were situated either within the limits of the lake or along its margin. On the western slopes of the Ochils, conglomerates of great thickness are entirely made up of the rounded fragments of the lavas and agglomerates of the adjoining range, thus indicating that the volcanoes which were at first subaqueous had reared their cones above the surface of the lake. Owing to the gradual submergence of the area, they were eventually submerged and buried underneath the accumulating sediment. The remains of true air-breathing insects

(Chilognathous myriapods of the genera *Kampecaris* and *Archidesmus*), associated with those of plants of the genera *Psilophyton* and *Arthrostigma*, are comparatively abundant in the finer sediments, and point conclusively to the close proximity of land.

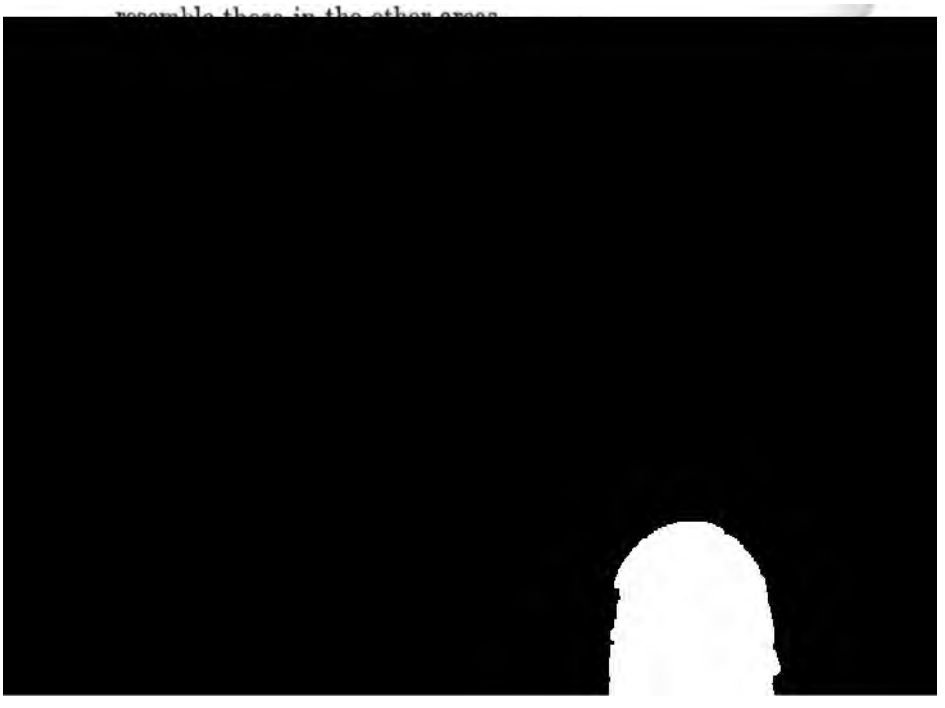
Along the southern margin of the central basin there is interesting evidence to prove that there must have been irregular movements of elevation and depression during the Lower Old Red Sandstone period. For example, in the neighbourhood of Lesmahagow, a perfect passage occurs from marine strata of Upper Silurian age into reddish beds, probably of lacustrine origin, indicating that an upward movement had elevated a portion of the sea-floor into a lake basin. A few hundred feet from the base, however, certain beds are found, almost identical with the underlying marine Silurian strata, and containing similar fossils pointing to a temporary removal of the barrier, and the return of marine forms. These marine bands are overlain by a great thickness of lacustrine deposits, till about 5000 feet from the base we find remarkable evidence of another return to marine conditions. At Carmichael, in Lanarkshire, a band of shale has yielded a graptolite, Orthoceras, Beyrichia, etc.—forms which must have survived in the open sea since Upper Silurian time. The conditions favourable to their existence in the Old Red

The Upper Old Red Sandstone strata of Scotland are separated from all older formations by a strong unconformability, indicating an upheaval of the continental area, and prolonged denudation of the old land surface, composed of the crystalline schists, together with Silurian and Lower Old Red Sandstone strata. On this land surface were still to be found some of the Old Red lakes, much reduced in size, but still containing a few of the descendants of the denizens of the Lower Old Red waters. In these land-locked basins the breccias, sandstones, and shales forming the upper division of the system were accumulated, and in these deposits were entombed the remains of such fishes as *Holoptychius* and *Pterichthys major*, while in the open sea the Carboniferous Limestone formation was being built up by marine animal life. As the land in the northern areas gradually sank, the lacustrine and littoral deposits were succeeded conformably by estuarine and marine strata of Lower Carboniferous age, and a much newer facies of fish fauna followed the Old Red types. This seems to me to be the explanation of the peculiar relations of the Upper Old Red Sandstone to the Lower Carboniferous rocks of Scotland. Sometimes the Upper Old Red strata are separated from the Lower Carboniferous rocks by an important development of volcanic rocks; but when this volcanic zone is absent, it is difficult to draw a boundary line between them. Notwithstanding this apparent passage, there is a wide divergence in the respective fish faunas, the Upper Old Red forms being more nearly allied to those of the lower division of the system than to the overlying Carboniferous species. This remarkable palæontological break in a conformable series of strata can be satisfactorily explained if we regard the Upper Old Red fishes as the survivors of an older fauna, still confined to land-locked basins, while the Carboniferous forms suddenly gained access to the Scottish area from the open sea, where they had developed at a much more rapid rate than their less favoured relatives.

The relations of the Lower Carboniferous rocks of Scotland to the Carboniferous Limestone formation of Central England have been satisfactorily proved by the researches of the officers of the Geological Survey of the latter kingdom.

Carboniferous Limestone group of the midland counties of England was laid down. The fauna was on the whole estuarine, though occasional fresh-water and land animals are met with. Marine forms resembling those in the Carboniferous Limestone occur in thin bands on several horizons throughout the group. These organisms, especially the brachiopods, though in places met with in large numbers, are confined to one or two species in each band, while the individuals are stunted and dwarfed as if they had lived in an uncongenial habitat. In the border territory, however, the marine fossils in some of these beds are as well developed and the species are as varied as those of the Carboniferous Limestone of central Scotland. This resemblance need not be wondered at, since the alternation of conditions must have been precisely the same.

In the different areas there is a strong similarity between the marine and estuarine forms of the invertebrata, the species being nearly identical. But the higher crustacea and the fishes, especially the ganoids, though closely allied, yet differ specifically—a distinction which may be accounted for on the supposition that they lived in different estuaries on opposite sides of the Silurian barrier. In the western area there are few marine forms present, the fossils being chiefly ostracods, but when marine organisms occur they resemble those in the other areas.



the zones of this series, especially the limestones, are traceable over the whole of the south of Scotland. This formation is divisible into three sub-groups: (1.) a lower, comprising limestones, sandstones, shales, coals, and ironstones; (2.) a middle, containing sandstones, shales, coals, and ironstones, with no limestones; and (3.) an upper, containing limestones, shales, sandstones, coals, and ironstones. This doctrine is perhaps better illustrated by this formation than by any other Scottish deposit, because it affords remarkable examples of the disappearance and reappearance of marine organisms in particular areas according to the physical conditions which prevailed. For example, the corals, crinoids, spirifers, productí, etc., so abundant in the lower marine limestones, are not met with in the middle subdivision, but the very same species reappear in the Upper Limestone group. It is apparent, therefore, that the marine organisms were compelled to migrate to a more congenial habitat during the deposition of the middle group, and as soon as the conditions became favourable for their growth they reappeared, having undergone but slight modification. The very same phenomena are observable on a smaller scale in the respective zones of the upper and lower subdivisions. When the succession is complete the following is the arrangement of the strata in ascending order:—(1.) limestone charged with ordinary marine fossils; (2.) shales yielding stunted marine forms; (3.) sandstone; (4.) fireclay with the roots of plants which is overlain by a coal seam. In some cases one or more of these members may be absent, but the others preserve the same relative order. The limestones indicate deposition in clear water where corals, crinoids, and other marine organisms found a congenial habitat; the shales point to the deposition of fine sediment, and the gradual silting up of the sea bottom, conditions which were unfavourable to the growth of marine life; while the sandstones indicate a further shallowing of the sea and the distribution of coarse sediment by marine currents. By degrees shallow lagoons and mudflats were formed, suitable for the growth of the vegetation now stored up in the seams of coal. The bed of limestone which frequently forms the roof of a coal seam

represents another depression of the land surface, and the return of marine organisms forming the first stage in the same cycle of physical conditions. It is evident that during the deposition of the middle coal-bearing group, where the limestones are absent, that the land could only have undergone a limited submergence after the accumulation of the vegetable matter. The depth of water was not sufficient to allow the marine organisms to migrate to those areas of deposit. From the data now adduced it is manifest that the existence of marine organisms in any particular area of deposit depended solely on the nature of the physical conditions, and when we remember that the same cycle of physical conditions must have been repeated again and again during the Carboniferous Limestone formation, we may be able to appreciate the vast amount of evidence in support of the ingenious doctrine propounded by Barrande.

After the deposition of the Millstone Grit the overlying Coal-measures point to fresh-water conditions or land surfaces. The latter were in all probability more extensive than those in the Carboniferous Limestone formation, and may have been connected with continental areas. This period was characterised by an incursion of the slowly migrating plants, which replaced to a large extent those met with in the lower coal-bearing series. It is a remarkable fact that some of the plants belonging to the true Coal-

terus. To me this discovery is particularly interesting, as I had been led to infer from the structure of the Carboniferous Eurypterus that it was a land animal. Additional proof in support of this conclusion was obtained by Sir W. Dawson in the old tree-stumps of the Joggins Coalfield, where he found masses of the test and the comb-like organs of a Eurypterus, besides the remains of reptilians, gally-worms, and a snail (*Pupa vetusta*)—all land animals and air-breathers.

The value of palæontological evidence in determining the geological position of strata is admirably illustrated in the case of the Elgin sandstones. In that region a series of yellow sandstones containing a remarkable reptilian fauna, found elsewhere in Triassic beds, overlie Upper Old Red Sandstone rocks with remains of *Holoptychius*. The physical relations of these two groups of strata are obscured by a great development of superficial deposits; but quite recently a section has been exposed in a quarry near New Spynie, in which the reptiliferous sandstones rest on the Upper Old Red strata, without any marked unconformability, save a thin band of conglomerate. With reference to the age of the red and yellow sandstones yielding *Holoptychius*, there has been no difference of opinion. They form part of a group of Upper Old Red Sandstone strata extending along the south shore of the Moray Firth. The overlying yellow sandstones containing reptilian remains have been generally regarded by geologists as belonging to the Triassic period ever since the publication of Huxley's monograph on the fossils derived from these beds. Notwithstanding the palæontological evidence, a few geologists still cling to the belief that the reptiliferous sandstones may eventually prove to be a higher portion of the Upper Old Red Sandstone. It seems to me, however, that there is an overwhelming amount of evidence supplied by the organic remains, in support of the Triassic age of these sandstones. The mere fact of finding reptilian remains or footprints is not enough to decide the question; but when we remember that these remains belong to true Crocodilians (*Stagonolepis*) and to Lacertilians (*Telerpeton*), it is sufficient to show that there is a great hiatus between the two sets of rocks. The evidence is still further strengthened

by the recent discovery of the skull of a Dicynodon in these sandstones, now in the possession of my colleague, Mr Linn, which was briefly described by our distinguished naturalist, Dr Traquair, at the Aberdeen meeting of the British Association. These reptilian remains have hitherto been obtained only from Triassic strata in other regions. It would, indeed, be rather remarkable if such highly-specialised animals as those whose remains are found in the Elgin sandstones should have continued without any modification from Old Red Sandstone to Triassic times. The discovery of reptilian remains in Old Red or Silurian rocks would not be in the least astonishing, but we should expect them to possess Labyrinthodont characters, or belong to a more archaic type.

The organic remains associated with the deposits of the Ice age help to throw light on some of the phases of that remarkable period. From evidence obtained over the greater part of Scotland, it is apparent that the boulder clay is a product of land ice. That such a formation should be almost barren of fossils is just what might be expected when we remember that the country must have been enveloped in ice, which radiated from a few centres, and invaded the surrounding shallow seas. The organisms that flourished on the old land surface previous to the advent of the glacial period have been almost entirely removed; and it is only at rare intervals that

in the boulder clay clearly show that the ice must have marched inland from the bed of the adjoining firth. In like manner, the ice which moved seawards from Strathmore was deflected towards the north after reaching the present coast-line, bearing along with it the *moraine profonde* derived from the Old Red Sandstone area. And so, also, the great *mer de glace* that streamed from the Great Glen into the basin of the Moray Firth must have crossed the north-eastern part of Aberdeenshire; while a portion of the same ice-sheet must have been deflected towards the north-west so as to over-ride a portion of Caithness. For our present purpose, it is of little moment whether these changes in the trend of the ice-flow in the Moray Firth were due to the fanning of the great glaciers, or to the presence of Scandinavian ice in the North Sea. It is enough to indicate that the direction of the ice-markings, the distribution of the stones in the boulder clay, and the organic remains, point to the conclusion that the Highland ice ploughed up the accumulated sediments in the basin of the Moray Firth, and deposited them over part of Caithness and the Orkney Islands, in the form of a dark, shelly boulder-clay. The assemblage of fossils in the Caithness and Orcadian boulder-clay is rather remarkable. Most of the shells are not of an Arctic type, but belong to species still living round our shores. Along with these, however, some extinct forms are associated. No less interesting is the occurrence of recent species of foraminifera in conjunction with species which must have been washed out of the chalk. The chalk foraminifera, like the chalk flints, were most probably derived from the pre-glacial denudation of Cretaceous beds which once fringed the Moray Firth basin. Almost all the shells in the Caithness boulder-clay which could retain traces of glaciation are smoothed and striated like the stones in this deposit. None is found in the places where they lived and died. It is a significant fact that few remains of shore shells have been met with, most of the shells being of the same species as those now inhabiting the sub-littoral zone of our islands. To some it has been a source of wonder that the shells of the Caithness boulder-clay are not of the same Arctic type as those derived from the glacial clays of

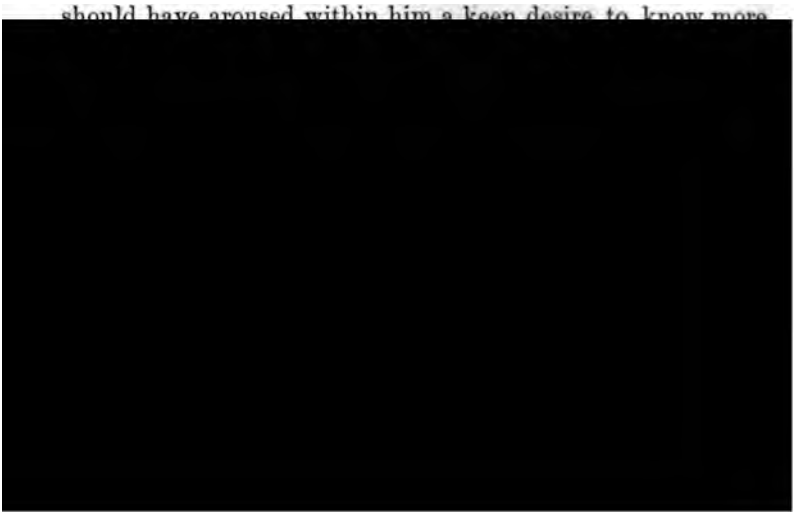
the Forth and Clyde; but this peculiar feature may be satisfactorily accounted for. The fossils found in the Caithness deposit represent the fauna that had lived and died on our shores before the advent of the glacial period, while those in the Forth and Clyde beds belong to the 100 feet sea-beach. The latter represent the Arctic species that approached our shores after the climax of glacial cold, when the ice retired from the shallow seas to the interior of the country, the water in the various fiords being kept at a low temperature by the melting of the inland ice. During the climax of the cold period represented by our boulder-clays, the ice-front was so far out to sea, that no marine organisms could reach our present shore-line. When the ice had completely disappeared, owing to the gradual amelioration of climatic conditions, the old denizens of our shallow seas returned again to their former haunts, while the Arctic forms migrated to the bottom of our deepest sea lochs, or vanished from our islands altogether.

On the south side of the Moray Firth there are beds containing shells in the position in which they lived and died. Intercalated between two boulder-clays, these deposits point to a warm inter-glacial period, when the ice must have retreated far into the interior of the country, and when the land was submerged to a depth of about 500 feet. When the relations of these beds, now being studied by several glacialists, are made known, I have no doubt that another interest

mous differential pressure to which they were subjected, they cannot be expected to yield distinct fossil forms. The strata, however, are not all equally crushed. Quite recently one of my colleagues—Mr Barrow—has obtained recognisable fossils like serpulites from the altered limestones of the Perthshire Highlands, and has found worm burrows in the quartzites. This discovery is of special interest, inasmuch as it shows that the beds are not utterly destitute of organic remains, and it encourages the hope that still more definite forms may be found.

West of a line drawn from Loch Eribol to Skye, the Archaean rocks lie beyond the area of the terrestrial movements of post-Silurian time. In the Archaean series there is little likelihood of organisms ever being found, for, so far as my observations have gone, in the North-West Highlands I have never seen a bed which could be regarded as of sedimentary origin. Indeed, the gneisses all bear evidence of having been formed by the crushing and recrystallisation of igneous rocks, their schistosity being due to mechanical movement of the particles produced by differential pressure. Between the formation of the Archaean gneisses and the deposition of the Cambrian conglomerates and sandstones an enormous lapse of time must have intervened. These sedimentary deposits might yield fossils, for, in certain areas, they lie comparatively undisturbed. From the coarse material of which they are composed, and the indications of rapid accumulation, we may naturally infer that they represent a great lacustrine formation. For this reason it is not probable that they will readily yield remains. There is nothing unreasonable in the supposition that they may be the equivalents of the Cambrian rocks of Wales, which have afforded some of the oldest fossils yet known. A small outlier of these Cambrian rocks caps the headland of Cape Wrath; and it is interesting to note that there, as elsewhere in Sutherlandshire, the component pebbles of the conglomerate are not derived from the underlying gneiss. A large percentage of the stones is made up of rocks of sedimentary origin, such as greywacke, quartzite, hardened shales, and cherty limestones, while a few consist of a slaggy diabase

lava. While reflecting on the history of these ancient strata, one cannot avoid asking the question—whence came these fragments of sedimentary and volcanic rocks that belong to a period intervening between the Archaean gneiss and the deposition of the basement beds of the Cambrian strata? And yet they plainly indicate that during that long cycle of time—which may be as long, or even longer, than that extending from the Cambrian period to the age in which we live—the same geological agencies were in operation. It cannot be doubted that, during the deposition of the strata from which the Cambrian pebbles were derived, forms of life of some sort must have flourished on the earth. It becomes, therefore, a matter of absorbing interest to search for relics of these strata which may throw light on this vast interval of time. Surely they may yet be met with, not converted into schists; indeed, there is every reason to hope that some traveller may light on them in some remote part of the globe like that described by Richthofen, where a rich fauna may be exhumed from strata older than those now known as the Primordial Zone. When studying palæontology at the School of Mines under my revered teacher Salter, I well remember how he spoke of his eager search in the Longmynd strata for fossils older than those of the Lingula flags. I could not then understand how the discovery of such a fossil as *Palaeopyge Ramsayi* should have aroused within him a keen desire to know more



I.—*On the Occurrence of the Bottle-Nosed or Beaked Whale* (Hyperoodon rostratus) *in the Scottish Seas, with Observations on its External Characters.*

By Sir William Turner, M.B., LL.D., F.R.S., Professor of Anatomy, University of Edinburgh; President of the Royal Physical Society.

(Read 20th January 1886.)

The term "bottle-nosed whale" is one which in popular speech is applied somewhat indiscriminately to various species of Cetacea. When used zoologically it is intended to designate that particular kind of toothed whale, which naturalists have now agreed to call, notwithstanding the inappropriateness of the name, *Hyperoodon*, and which is represented in the North Atlantic by the species *rostratus*. The name *Hyperoodon* applied to this genus of cetacea was given to it by the French naturalist, M. Lacepède, who stated that the palate (ὑπερῷη) was rough, with "very small, unequal, hard and pointed teeth."[1] This statement purports to be based on the dissections made by M. Baussard of a large female and young female captured near Honfleur in September 1788. On referring, however, to M. Baussard's description,[2] I find he does not state that these animals were provided with palatine teeth, but that the palate in the young animal was furnished "with small, hard and sharp points, d'une demiligne d'elevation, and rather unequal," and that they were somewhat longer and stronger in the mother than in the calf. The presence of palatine teeth in a mammal would indeed be contrary to all experience.

The first definite evidence of this whale was obtained as far back as 1717, when on 23d September a young female, 14 feet long, was stranded at Maldon in Essex. It was examined and figured as the bottle head or flounder's head by Mr Samuel Dale,[3] who also stated that another of this

[1] Histoire Naturelle des Cétacées, Paris, p. 320.

[2] Observations sur la Physique, sur l'Histoire Naturelle, etc., March 1789, p. 201, tome xxxiv.

[3] History and Antiquities of Harwich and Dovercourt, by Silas Taylor, with Appendix on the Natural History, by Samuel Dale, p. 411, Pl. xiv., London, 1732.

kind, 21 feet long, was caught about the same time near the mouth of the same channel at Bradwell-juxta-Mare. In 1783 the famous John Hunter obtained a female specimen in the Thames, many points in the anatomy of which are described in his classical essay "On the structure and economy of whales,"[1] and the skeleton of which is preserved in the Hunterian collection in the Museum of the Royal College of Surgeons of England. Since that date other specimens have from time to time been recorded as seen on the English coast. For example, Mr James (now Sir James) Paget, in his Catalogue of the Fauna and Flora of Yarmouth,[2] states that one was caught in November 1816, and a smaller specimen about twenty years before; one was captured in the Humber in 1837, the skeleton of which is in the Hull Museum;[3] one in September 1839 at Flimby, near Cockermouth;[4] probably another on East Hoyle Bank, also in September 1839; apparently a female, taken at Aust Passage, on the Severn, in October 1840, the skeleton of which has been preserved in the Bristol Institution;[5] a young male on the coast of Devonshire in September 1846, the skeleton of which is in the Museum of the College of Surgeons of England;[6] three specimens near Liverpool in 1850, 1852, and 1853 respectively;[7] that caught at East Hoyle Bank in the month of August 1853 is said

and a young one near the same place; a female taken at Weston-super-Mare, and measured by Mr Crotch;[1] an adult female and a young one in October 1860 at Whitstable in Kent, the skeleton of the adult and a part of that of the young animal are in the British Museum;[2] an adult female in the Menai Strait in September 1877;[3] the skull of an adult male recorded by Mr Thomas Southwell as brought up in a trawl in March 1881 on the Great Fisher Bank, and now in the Norwich Museum.[4]

M. Gervais, in the chapter on Hyperoodon in the *Ostéographie des Cétacés*, by M. van Beneden and himself, has given a record of a number of specimens of this whale captured on the coasts of France, Belgium, and Holland. The estuaries of the Seine and the Scheldt have frequently been resorted to by these cetaceans in the summer and autumn seasons, and the museum at Caen in Normandy contained at one time three crania and also an entire skeleton of this animal. One of these skulls is probably that of the female caught at Honfleur with its young one in September 1788, which has been already referred to as described by M. Baussard. A specimen taken at Zandvoort, on the Dutch coast on 24th July 1846, was dissected by Vrolik, and formed the subject of the most complete account of the anatomy of this animal which has yet been published.[5]

Hyperoodon rostratus has also been captured on the coasts of Scandinavia, and specimens are referred to in the cetological writings of Pontoppidan, Eschricht, Nilsson, Lilljeborg, and Malm.

The first specimen of *Hyperoodon* to be recognised as having an Irish habitat was stranded at Killiney, near Dublin, in September (1824?), and was described by Dr A.

[1] J. E. Gray on *Hyperoodon* in Proc. Zool. Soc., 1860, vol. xxviii., p. 422; and Catalogue of Seals and Whales, p. 334.

[2] Rev. G. Beardsworth in Proc. Zool. Soc., 13th November 1860, vol. xxviii., p. 373.

[3] Zoologist, 3rd series, 1878, vol. ii., p. 13.

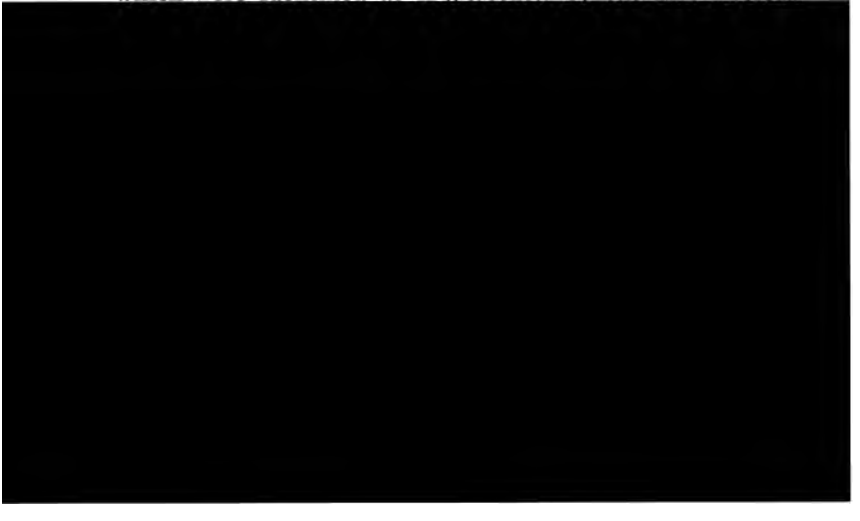
[4] Zoologist, 3rd series, 1881, vol. v., p. 258. I am indebted to Mr Southwell for some of the above references.

[5] Natuurk. Verhandel. van de Hollandsche Maatsch. der Wetensch. te Haarlem, 1848.

Jacob in an admirable memoir published in 1825,[1] in which he showed the inapplicability of M. Lacepède's generic name, and suggested instead *Ceto-diodon.* The skeleton of this animal is preserved in the Museum of the Royal College of Surgeons in Dublin. Subsequently the late Mr William Thompson of Belfast wrote and published two papers of notes of eight other specimens captured on the coast of Ireland up to the end of October 1845,[2] and it is stated that five of these were taken in the months of either August, September, or October. The crania of three Irish specimens of Hyperoodon are preserved in museums in Dublin, in addition to the skeleton of the animal described by Dr Jacob; and the skull of the specimen captured in Belfast Lough, 29th October 1845, is preserved in the Belfast Museum.

Mr W. Thompson, in the first of his papers on bottle nosed whales, refers to a newspaper account of two speci mens captured together in October 1839 in Lochryan, Wig townshire, which he thought from their size might be examples of *Hyperoodon.* Although their sex is not stated it is not unlikely that they were a mother and a your one.

In October 1845 an adult female and a young femal which were identified as *Hyperoodon* by the late Profess



autumn, near Alloa, with preparations." To the best of my knowledge, this paper was not printed, as the publications of the Wernerian Society had ceased to take place some years previous to that date. Fortunately, however, a few facts about these animals have been preserved by Mr William Thompson in the second of his papers on bottle-nosed whales. He states that he was in Edinburgh on 31st October 1845, two days after the capture of the *Hyperoodon* in Belfast Lough above referred to, and to his astonishment met in the street the carcase of a *Hyperoodon* being carted to the Zoological Gardens to be cleaned, and the skeleton prepared for the Museum of the University. From Mr Goodsir and his assistant, Mr Melville, he ascertained that this whale was killed in the Firth of Forth on 29th October, that it "measured 28½ feet in a line from the tip of the snout to the middle of the caudal fin, not following the curvature, but as if a plumb-line were dropped from one point to the other. It was a female, and was accompanied by a young female (9 feet long measured in the same way), which was still sucking; the mammæ of the mother were distended with milk, which appeared very rich in butter, and tasted pleasantly."

Since the year 1854, when I was appointed Demonstrator of Anatomy in the University by the late Professor Goodsir, I have been acquainted with the bones of a *Hyperoodon* in the University Museum, which, though unmarked, I have always regarded as the specimen taken at Alloa.[1] So long as the osteological collection was housed in the University buildings in the South Bridge, through want of room these bones were not articulated; but when I moved the collection to the Anatomical Museum in the new buildings of the University some months ago I had this skeleton articulated and suspended. The bones were all completely ossified, for the epiphyses were all united to their respective diaphyses. As articulated, the skeleton measured in a straight line from the tip of the lower jaw to the last caudal vertebra, 23 feet 8 inches; and the extreme length of the skull in a straight

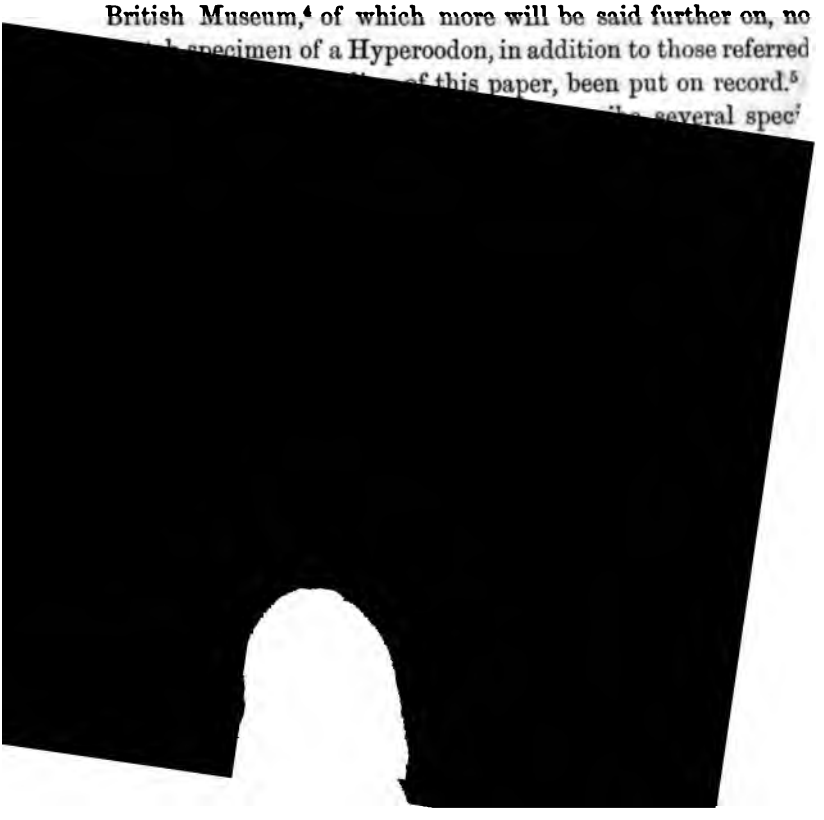
[1] Through a clerical error in Mr E. R. Alston's "Fauna of Scotland," Glasgow, 1880, this specimen is said to have been caught at Queensferry.

line from the tip of the mandible to the most projecting part of the occipital condyle was 5 feet 4½ inches.

Owing to a careless reading of Mr Wm. Thompson's article, in which reference is made to this specimen of *Hyperoodon*, the late Dr J. E. Gray, in his paper "On the Genus Hyperoodon: the Two British Kinds and their Food,"[1] wrote that it was obtained on the 29th October 1839. He repeated this error twice in his "Catalogue of Seals and Whales," pp. 331, 339; and those authors who have followed his guidance without referring to the original authority have again repeated it, so that it is now wide spread in cetological literature.[2] In future I hope that the correct date (1845) will be given when this specimen is referred to.

In August 1871 a Hyperoodon was stranded alive at Fraserburgh, on the coast of Aberdeenshire. Dr Struthers has recorded[3] some particulars of this specimen. It measured along the curve of the back 20 feet 9 inches, and in a straight line 19 feet 3 inches. It was believed to be a male, though its sex was not precisely ascertained. It was not an adult, for the epiphyses of the bodies of the movable vertebræ were all separate.

With the exception of a skull from the Orkneys in the British Museum,[4] of which more will be said further on, no [illegible] specimen of a Hyperoodon, in addition to those referred [illegible] of this paper, been put on record.[5]



which Mr Anderson subsequently sent me in a letter, I gathered that the animal was a Hyperoodon, and I purchased the skull and so much of the rest of the skeleton as had been preserved, and placed the bones in the Anatomical Museum of the University. Mr Anderson wrote to me that "the whole length of the whale, from the tip of the nose to the tail, was 23½ feet, and the spread of the tail was 4½ feet. The upper and lower jaws were very small and pointed. The beak was 1 foot 9 inches from the tip to the end of the opening of the mouth. The head rose abruptly from the base of the beak. The dorsal fin was behind the middle of the back." That this whale was *Hyperoodon rostratus* I at once recognised when the skull reached me, and from the complete ossification of the vertebræ it was obviously an adult specimen. I received no information as to its sex, but it was most probably an adult female.

In 1879 I read in the *Scotsman* newspaper, September 24th, that a whale had been captured at Grangemouth, on the Firth of Forth, on the previous day. I went to see the animal, and made some notes of its dimensions and appearance. It was a female *Hyperoodon rostratus*, and its greatest length in a straight line was 26 feet. Its greatest girth two feet behind the pectoral limb, was 15 feet. From the angle of the mouth to the tip of the upper jaw, 24 inches; and from the same to the tip of the lower jaw, 25½ inches. The blow-hole was transverse, and situated 7 inches behind a line drawn vertically from the eye to the top of the head. The head swelled out into an eminence at the base of the beak, and contrasted strongly with the attenuated beak and short cleft of the mouth. The falcate dorsal fin, 19 inches high, was behind the middle of the back, and a line from its anterior border fell vertically 9 inches in front of the vulva. From the umbilicus to the front of the vulva was 3 feet 6 inches. A nipple was seen on each side of the vulva, and the anus was immediately behind it. The breadth in a straight line between the lobes of the tail was 6 feet 4 inches. The body was cylindriform between the pectoral limb and dorsal fin, and was laterally compressed from the region of the dorsal fin to the root of the tail. In colour the animal

was dark slaty grey on the back and sides; lighter grey, but never white, on the belly, the sides of the upper and lower jaws, and the angle of the mouth. No teeth were visible, but a groove was seen along the edge of the gum. This whale was sold by the Custom House authorities for exhibition at the Birmingham Aquarium.

A few days afterwards I heard from the officers of Customs that a smaller whale of the same kind had been found dead on September 24th, on the shore at Blackness, a few miles lower down the Firth of Forth, and also sold. I traced it with the view of procuring the skeleton, but found that the bones had been broken up for manure. This animal was said to be only 14½ feet long, and was without doubt the young of the larger female stranded at Grangemouth on September 23d.

In September 1883 two whales were stranded at South Queensferry, and purchased by an oil merchant in Kirkcaldy. From the description which he has given me they were clearly two specimens of *Hyperoodon*, probably mother and calf. Their bones were not preserved. In the beginning of October of the same year a whale about 19 feet long was stranded at Loch Ranza, in the island of Arran. Through the kindness of Dr Neil Fullarton, of Brodick, I obtained the

When placed on its belly at full length, it measured in a straight line 20 feet 6 inches from the tip of the lower jaw to the mid-point of the tail; but when the tape-line followed the curvature of the back it was 22 feet 4 inches long. The beak was attenuated, and only 13 inches long, and the lower jaw projected scarcely one inch beyond the tip of the beak. The mouth slit was 21½ inches long, and no mandibular teeth were seen projecting through the gum. At the base of the beak the head ascended rapidly and almost vertically, though with a slight convexity forward. It presented a boss-like protuberance looking directly to the front, and measuring from the base of the beak 19 inches high by 13 inches wide. It gave to the front of the head a highly characteristic appearance. Behind this boss the outline of the head showed a slight depression; behind which, again, the outline of the back ascended by a gentle curve to the highest point of the back, which in a vertical line was 3 feet 11 inches above the platform on which the whale rested. The highest point of the head in a vertical line was only 2 feet 10 inches from the platform. From the highest point of the back, which was about midway between the root of the pectoral fin and the inferior border of the base of the dorsal fin—being 3 feet 9 inches from the latter—the outline of the back sloped gently backwards and downwards to the dorsal fin. Behind the dorsal fin the outline of the back descended very rapidly to the tail, and along this rapid descent the summit of the back was keeled, and the keel was prolonged for a short distance on to the dorsum of the tail. The sides of the body between the plane of the dorsal fin and the tail were flattened, receded from before backwards, and had a very slight convexity from above downwards. In front of the dorsal fin the body was much more bulky, and with convex sides. A depression running antero-posteriorly marked the lower border of the convexity, due to the great mass of muscles of the back. The widest part of the head was between the two eyes, and the greatest width of the body only slightly exceeded the widest part of the head.

The dorsal fin was behind the middle of the back; it had a convex anterior border and a falciform posterior border.

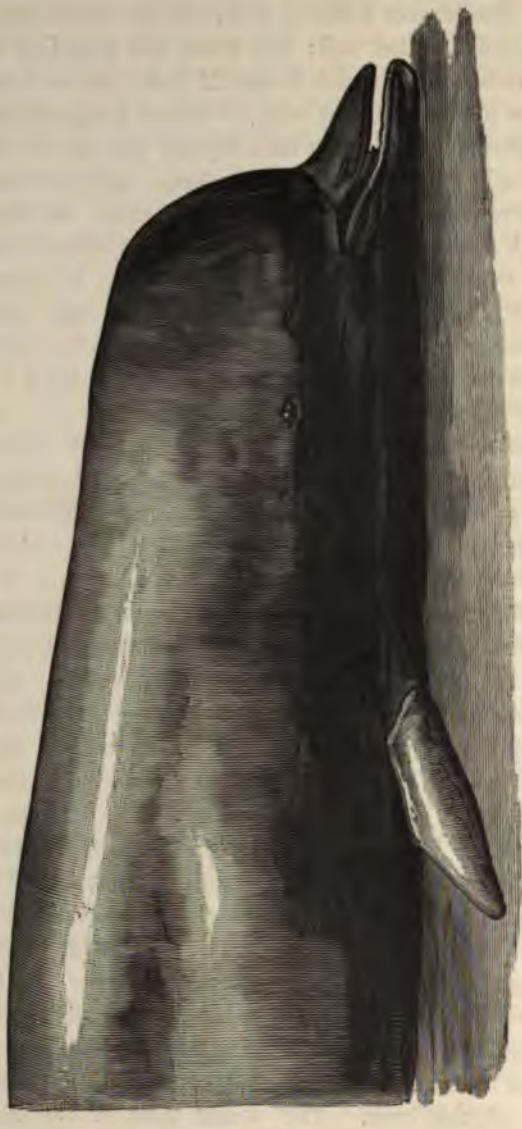


Fig. 1.

Profile of the head and anterior part of the body of young male *Hyperoodon rostratus*. This and Fig. 2 are from photographs kindly taken for me by J. Stewart Smith, Esq., and were cut in wood by Mr D. L. Turnbull.

Its height was 12¾ inches, and the antero-posterior diameter at the base was 18 inches. The anterior border of the base of the dorsal fin was 8 feet 7 inches in front of the middle of the tail, and 13 feet 5 inches behind the tip of the upper jaw. The lobes of the tail were attenuated at the tips, which projected further back than the middle of the tail, so that the outline from tip to tip was concave. But there was no median notch on the posterior border, which, indeed, was slightly convex at and immediately on each side of the middle of this border. The breadth of the tail from tip to tip was 5 feet 7 inches.

The flipper was remarkably small for so large an animal. Its length was 2 feet 5 inches, and its antero-posterior diameter at the base was 8½ inches. The anterior border of its base was 5 feet 5 inches from the tip of the lower jaw. The anterior border was slightly convex in its whole length. The posterior border was thin, at first almost straight, and then curved rapidly forward to the point or tip.

The blowhole on the top of the head was transverse, with the two ends a little bent forwards, so that it was slightly

Fig. 2.
Three-quarter face view of the head, the body being foreshortened.

concave in front. Its transverse diameter was 5 inches, and it was not divided on the surface into two nares. Its dis-

tance from the anterior border of the root of the dorsal fin was 9 feet 8 inches. The eye as it appeared between the two lids was small. It was almost in a direct line with the angle of the mouth, and 19 inches behind it. The orifice of the ear, which would only admit a probe, was in line with the back of the eye, and 7 inches behind it.

The ventral surface of the whale showed a pair of lateral furrows in the integument of the under surface of the head, which began 16 inches behind the tip of the lower jaw, and extended for 19 inches backwards from their commencement. Each groove was about half an inch deep. At their commencement they were only $2\frac{1}{4}$ inches asunder, but they diverged from each other as they passed backwards, and the posterior end of each was bent outwards, so that they included between them a triangular area of integument. The penis protruded through a mesial furrow in the belly, and its place of protrusion was 8 feet in front of the middle of the tail, and $13\frac{1}{2}$ inches in front of the anal slit. This slit was $4\frac{1}{2}$ inches in antero-posterior diameter. The umbilicus was $22\frac{1}{2}$ inches in front of the spot where the penis protruded. The anterior border of the dorsal fin was in a plane midway between the umbilicus and the place of protrusion of the penis.

It is difficult to describe the colour of this *Hyperoodon*.

the boss-like protuberance above the beak it was 2½ inches thick; but subjacent to the blubber was a mass of much softer yellow fat, about 9 inches thick, out of which the oil could easily be squeezed. When this was cut through, the space between the maxillary ridges of the skull was opened into, and from it a quantity of almost pure yellow oil flowed. Immediately in front of the blowhole and nasal passages the sub-cutaneous tissue consisted of a thick and dense fibrous layer, in which some fat was infiltrated. The skeleton of this *Hyperoodon*, when cleaned, will be articulated and suspended in the Anatomical Museum of the University of Edinburgh.

I shall now specially refer to some points in the external configuration of *Hyperoodon*, and consider them in connection with corresponding parts in other Ziphioids, and in the Sperm whale.

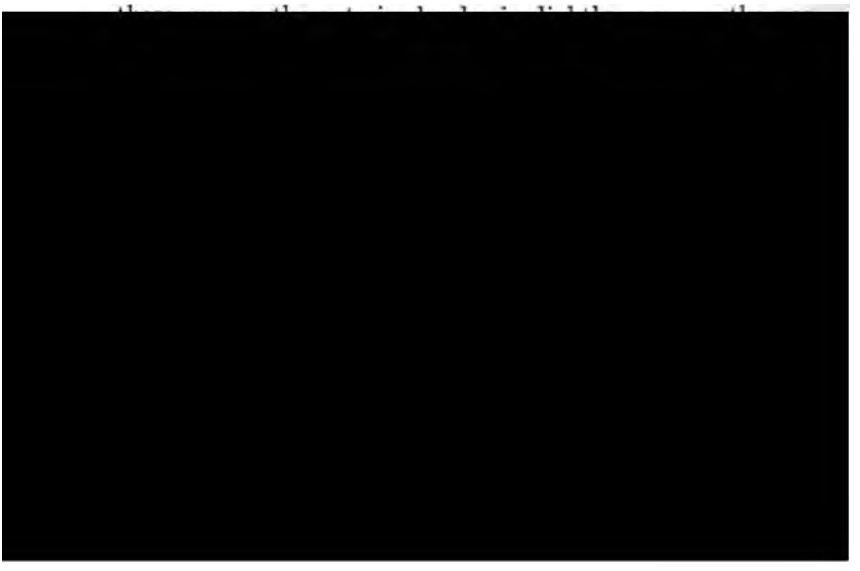
I have described on the ventral surface of the head and neck of the Dunbar specimen a pair of shallow diverging furrows in the integument. In the Belfast specimen (29th October 1845), recorded by Mr William Thompson, Mr James Bryce described "the marking at each side from behind the lip, extending under the chin in the direction of the belly, is 14 inches in length; in breadth it is 2 inches anteriorly and 9 inches posteriorly." By the term "marking" he obviously meant the triangular area between the diverging furrows. Mr Melville, who assisted in the dissection of the Alloa specimen, stated, in a note recorded by Mr W. Thompson, that he "forgot to ascertain the point at which the triangular process of skin under the throat commenced posteriorly, but anteriorly it reached to the middle of the lower jaw." Eschricht referred to a similar pair of furrows; and the Rev. Mr Beardsworth saw them in the specimen stranded near Whitstable, Kent, in 1860.

Furrows of a similar kind were described by Sowerby in the *Mesoplodon bidens* stranded at Brodie, Elgin, in 1800.[1] They are figured as meeting anteriorly in the Irish specimen of this whale recorded by Mr W. Andrews. Professor Reinhardt saw them in the specimen caught at Hevringholm

[1] British Miscellany of New or Rare Animals, vol. i., p. 1, 1806.

Strand.[1] They were also seen in both of the Shetland specimens of Sowerby's whale, which I have described,[2] and in my summary of the external appearance of this animal I have given "a pair of furrows converging in front on the under surface of the throat" as one of the characters. They were present, also, in the Ziphioid whale described by Burmeister as *Epiodon australe*,[3] but which is probably the same as *Ziphius cavirostris*. Hence their presence is a character to be looked for in the sub-family of Ziphioid whales. But if one may rely on the accuracy of Fig. 7 in Pl. XIX. of Chamisso's Memoir, "Cetaceorum maris Kamtschatici," it would appear that in the sperm whale (*Physeter macrocephalus*) a similar pair of converging furrows meeting in front, as in Sowerby's whale, existed. Hence, one may extend the generalisation, and state that in the whole family of the Physeteridæ a pair of converging furrows is present on the ventral surface of the head. The presence of these furrows is interesting as furnishing an approximation, in this family of whales, to the much more extensive and well-known fluted appearance of the belly, seen in the Rorquals or Balænopteridæ.

In *Hyperoodon*, *Mesoplodon*, and *Ziphius*, the pectoral limb or flipper is small in relation to the size of the animal. In all



The published figures of *Hyperoodon*, in which the tail is so placed as to enable one to see its shape, do not always correspond in their representation of the posterior border. In Dale's figure[1] of the Maldon specimen this border is shown as if notched at its mid-point, as is the case, for example, in the whalebone whales. In Hunter's figure[2] of the Thames specimen the tail is also represented as notched mesially. In Vrolik's figure[3] of the Zandvoort specimen, and in Dr Gray's figure of a specimen taken at Aust Passage in October 1840, a similar notch is also shown. But in Baussard's figure of the Honfleur specimen (*op. cit.*, Pl. I.) this border is not notched; and Captain David Gray both figures and describes the tail, instead of being notched in the centre, as round in the middle.[4] My observations on the Dunbar specimen also showed that instead of a mesial notch there was a slight projection at and immediately on each side of the middle of the posterior border of the tail; so that the figures in which a mesial notch is represented are in this respect inaccurate. I have described and figured a similar form of tail in *Mesoplodon bidens*,[5] and Burmeister has figured[6] the tail of his *Epiodon (Ziphius)* as possessing the same shape. Hence the absence of a mesial notch, and the presence of a slight convexity in the middle of the posterior border of the tail, is a family character in the Ziphioid whales. In the sperm whale, again, according to Beale[7] and to Bennett, a slight notch or depression posteriorly is situated between the two lobes of the tail.

Owing to M. Baussard's description of the palate in the Honfleur *Hyperoodon*, and the interpretation, though erroneous, put upon its structure by M. Lacepède, I was natu-

[1] This figure is copied by Pennant in "British Zoology," vol. iii., pl. vii., 1812.

[2] Phil. Trans., vol. lxxvii., pl. xix. This figure is copied into Bell's "British Quadrupeds."

[3] *Op. cit.*, pl. i.

[4] Proc. Zool. Soc. London, Dec. 19, 1882. See also his figures 1-5.

[5] Journal of Anat. and Phys., Oct. 1885, vol. xx., pl. iv.

[6] Anales de Museo Publico de Buenos Aires, Entrega quinta, tom i., pl. xv.

[7] Natural History of Sperm Whale, p. 24, and fig. on p. 23; also Bennett's "Whaling Voyage round the Globe," vol. ii., p. 156; London, 1840.

rally led to examine with care the roof of the mouth in the Dunbar specimen. The palatal mucous membrane was not uniform in appearance. In the anterior third it was studded generally with very short papillæ—so short, indeed, that they would probably have been overlooked if my attention had not been directed specially to them. In the middle and posterior two-thirds the palatal mucous membrane was quite smooth in the centre of the palate; but on each side, up to the groove that marked the junction of the palate and upper lip, it was studded with multitudes of short papillæ, some of which were sharp, others truncated, and which were so stunted as to be very slightly elevated above the general plane of the mucous membrane.

I shall now pass to the consideration of the dentition of *Hyperoodon*, and shall describe what I have seen in connection with both the lower and upper jaws; and in working out the dissection which was required I have been aided by my museum assistant, Mr James Simpson. When the gum was removed from the tip of the lower jaw, the points of a pair of mandibular teeth were exposed about half an inch from the surface. The crowns of these teeth were about half an inch long, and the fangs were imbedded in the mandible. On shaving off thin slices of the gum, for about three inches behind each mandibular tooth, the sacs of seven rudimentary denticles were exposed in the substance of the gum. Each sac, with a single exception, was not larger than would contain a big shot, and each contained a soft uncalcified or partially calcified denticle representing the crow of a tooth. These sacs were separat from each other by intervals of not m than half an inch. Behind the last these sacs, up to the posterior end of

Fig. 3.
Gum of a portion of one side of the lower jaw behind the mandibular tooth. The surface of the gum has been shaved off to show the tooth pulps and sacs. This and the succeeding figure have been drawn by my son, Mr W. A. Turner.

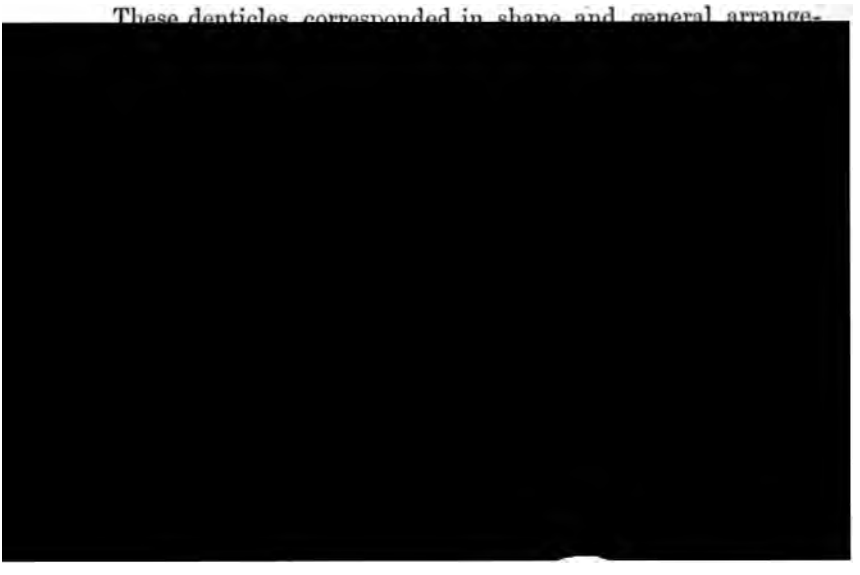
symphysis, no other sacs were seen; but behind the symphysis there were found in the substance of the gum on each side rudimentary calcified denticles, six in number on the right side and four on the left. Each denticle was about a quarter of an inch long, and had a simple conical form. These rudimentary teeth were separated by intervals of three quarters of an inch. Each tooth lay horizontally or obliquely in the gum, and was surrounded by an ill-defined sac, to the wall of which it was partially adherent. The symphysial part of the lower jaw was covered by a smooth mucous membrane; but where it became continuous with the gum it was faintly roughened with minute papillæ.

A distinct groove marked the junction of the palate and the upper lip. At the posterior end of this groove, on each side, a rudimentary pointed tooth about a quarter of an inch long projected through the mucous membrane into the mouth, and was so loosely attached to the gum as to be movable to and fro. Five additional and similar teeth were situated on each side, in antero-posterior series, in front of the one just described; but they were concealed in the gum, which had to be partially removed in order to expose them, their depth from the surface increasing from behind forwards. The most anterior of these denticles was 12 inches behind the anterior end of the upper lip. But, further, on dissecting the gum which covered the left side of the upper jaw at its anterior end, a tooth sac three-sixteenths of an inch in diameter was exposed, which was filled by a denticle slightly calcified on the surface, but soft within; but there was none on the right side. Dissections of

Fig. 4.
Portion of the gum of the left half of the upper jaw. L, lip; D, dentary groove, in which four calcified denticles have been exposed by dissection. The denticle marked x projected through the gum into the cavity of the mouth.

the rudimentary teeth and of the palatal mucous membrane are preserved in the University Museum.

It is known that in *Hyperoodon rostratus* teeth have not generally been recognised as protruding through the gum into the cavity of the mouth of the living animal, so that it appears to be edentulous. When the gum is removed, however, from the anterior end of the lower jaw, two well-known distinct teeth are exposed lodged in the mandible near its tip, from the presence of which the specific name *bidens* has sometimes been applied to this animal. Occasionally, however, a second mandibular tooth, also concealed by the gum, has been recognised close behind the first. Chemnitz found a second smaller tooth on one side of the jaw of his specimen, but not on the other.[1] Schlegel said[2] that the skeleton in the Leyden Museum had two teeth on the right side of the mandible upwards of an inch apart, and only one on the left side. Mr Wm. Thompson figured[3] two mandibular teeth about an inch asunder on each side of the jaw of the Belfast skeleton. The most complete account of the dentition of *Hyperoodon* has, however, been given by Eschricht,[4] who, in his admirable memoir on this animal, described, in a specimen which he dissected, not only the two well-known mandibular teeth, but a series of small denticles in each side of each jaw. These denticles corresponded in shape and general arrange-



specimen, and of more than two in Eschricht's animal, they were so small, and their attachment to the gum so insecure, that they could have had no function. In Sowerby's whale (*Mesoplodon bidens*), both Gervais and Reinhardt have described rudimentary teeth, other than the two well-known mandibular teeth of this animal. In a species of *Mesoplodon* described by Von Haast, rudimentary denticles were seen. In Burmeister's *Ziphius*, and in a *Ziphius cavirostris* examined by Gervais, a similar arrangement was observed. It follows, therefore, that, in all the genera of the Ziphioid sub-family which have been most completely studied, rudimentary functionless denticles occur in addition to that pair of mandibular teeth which usually assume considerable dimensions, though in *Hyperoodon* these teeth, seeing that they do not pierce the gum, are also functionless. The dentition of the Ziphioids so far, therefore, as regards the number of tooth pulps, is as complete, or almost as complete, as in the Delphinidæ, although they do not, with the exception of one pair of mandibular teeth, attain a similar development.

Another point which especially requires attention, is the shape of the head and skull. It is well known that the late Dr J. E. Gray described and figured[1] a cranium in the British Museum, which had been obtained from the Orkneys, as a distinct species by the name of *Hyperoodon latifrons*, and subsequently he gave it the generic name of *Lagenocetus*. This skull was distinguished from those of *H. rostratus* usually found in museums, by having the maxillary crests much higher than the frontal crest, and so much broader and thicker that they almost met mesially. Although many zoologists accepted *H. latifrons* as a good species, yet, the eminent cetologists, Professors Gervais[2] and Eschricht,[3] were not satisfied that it was distinct, and regarded the great development of the maxillary crests merely as a mark of age, and of the male sex. Dr Gray, in his various controversial writings on this subject,[4] was in the habit of referring to the

[1] Zoology of Voyage of "Erebus" and "Terror," 1846, p. 27, Pl. iv.

[2] Ostéographie des Cétacés.

[3] On the Gangetic Dolphin—Ann. and Mag. Nat. Hist., 1852, vol. ix.

[4] On *Hyperoodon latifrons*—Annals of Nat. Hist., second series, vol. ix., p. 407. Catalogue of Seals and Whales.

skull of the adult female *Hyperoodon* captured at Alloa, in the Anatomical Museum of the University of Edinburgh, as, from the form of its skull, a specimen of *H. latifrons*. In a correspondence which I had with Mr Thomas Southwell, of Norwich, some time ago about this specimen, I stated to him that it did not possess the broad lofty crests which Dr Gray gave as the specific mark of *H. latifrons*, so that, as Mr Southwell very properly has pointed out, the only instance adduced by Dr Gray in favour of his new genus, in which the sex was said to have been noted in the flesh, is disposed of.[1] I can give no explanation of how Dr Gray came to regard the specimen from Alloa as like the Orkney skull with the broad and lofty maxillary crests, for, so far as I know, its skeleton has not been described, and a mere glance at the specimen would satisfy any one, that in its entire configuration, it resembled the usual figures of the skull of *H. rostratus*.

But the question of the specific distinctness of *H. latifrons* has recently been set at rest by the observations of the enterprising whaling seaman, Captain David Gray, who has especially applied himself to the capture of *Hyperoodon* for commercial purposes.[2] From the large number of specimens which he has killed, of both sexes and of various ages, he has been able to show that the skulls with narrow maxillary crests are those either of females or young males; and he

to the front of the animal's head an abruptly vertical profile, so well seen in Captain Gray's figures, which at once distinguishes it from the convex profile of the female and young male.

I shall now give some comparative measurements of the four crania of *Hyperoodon rostratus* in the Anatomical Museum of the University of Edinburgh :—

	Alloa. ♀	Hamna Voe. ♀	Loch Ranza. ♂ *juv.*	Dunbar. ♂ *juv.*
	ft. in.	ft. in.	ft. in.	ft. in.
Extreme length of skull,	5 4½	5 2	Tip of beak broken.	4 5½
From occipital crest to tip of upper jaw,	4 10½	4 7		4 3½
Projection of lower jaw beyond upper,	0 1	0 0½	.....	0 1
Diameter of interval between summits of maxillary crests,	0 5½	0 6½	0 5½	0 6¾
Diameter of interval between bases of maxillary crests at posterior border,	0 6¾	0 8½	0 6½	0 5
Greatest transverse diameter of skull at post-orbital processes,	2 6	2 4½	1 8½	.....
Height of skull at occipital crests,	Max. crests 1 in. lower than highest point of skull.	1 10	1 5	1 11¼
Height of skull at maxillary crests,		1 10	1 5¾	1 9¾

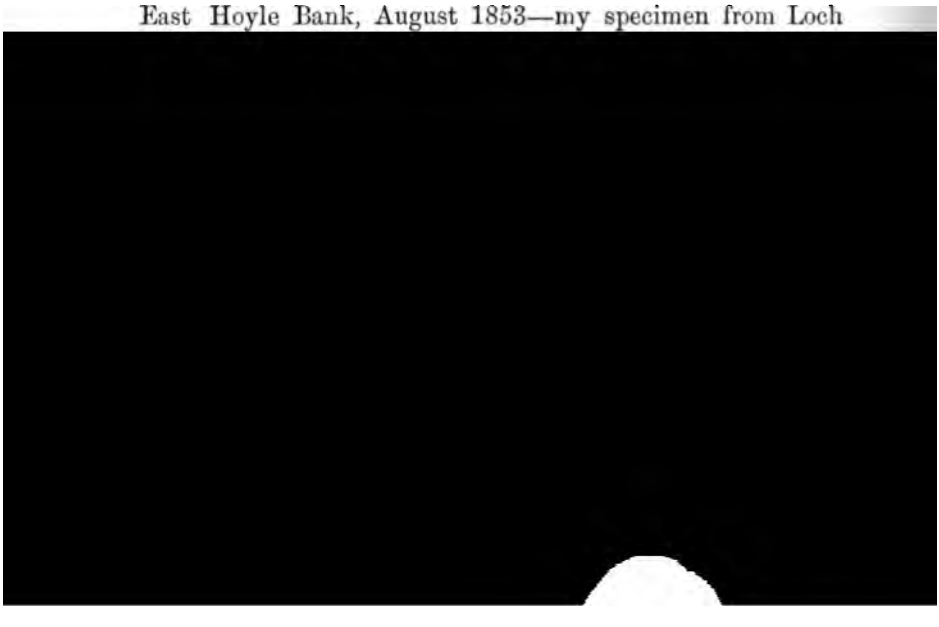
I have been careful to name the months in which the specimens of *Hyperoodon* for the first time recorded in this paper were captured, as they corroborate the statements made by other naturalists that the autumn is the time when *Hyperoodon*, in its annual southward migration from the Arctic Ocean, visits the coasts of North-Western Europe. Our best authorities on the geographical distribution and migration of this whale are the late Professor Eschricht[1] and Captain David Gray of the whaling steamer "Eclipse," [2] and the latter authority states that *Hyperoodon* is not seen in summer further south than a day's sail from the ice. September and October are the two months in which it most usually has

[1] Die Nordischen Wallthiere, Leipzig, 1849.

[2] Proc. Zool. Soc. London, Dec. 19, 1882, p. 726.

been captured in the British Islands, or on the coasts of France, Belgium, and Holland; two or three have been taken in August, but Vrolik's specimen was obtained at Landvoort in July; one of Sir James Paget's specimens was captured in November, my Dunbar specimen early in November, and a female recorded by Lilljeborg,[1] caught in 1749 at Frederikshall, on the coast of Norway, as late in the year as 17th November. The capture of this last-named animal has an especial interest, as a picture of it was in the possession of Linnæus. Lilljeborg states, on the authority of Professor Nilsson, that a female about 26 feet long was stranded at Landskrona, in Sweden, in April 1823: probably this animal was migrating northwards for the summer season.

A few words may now be said as to the sex of the specimens captured on the coasts of Western Europe. With very few exceptions they have been females, and not unfrequently each female has been accompanied by a young calf. But occasionally an immature male has been secured. Thus the specimen taken in Belfast Lough in October 1845, described by Mr Wm. Thompson—that taken on the Devonshire coast in September 1846, the skeleton of which is in the Museum of the College of Surgeons of England—a specimen taken on East Hoyle Bank, August 1853—my specimen from Loch



their return journey in the spring, keep further out to sea than do the adult females and younger animals.

In conclusion, I may state that I have preserved the greater part of the viscera of the Dunbar *Hyperoodon*, and my examination of these will give, I hope, material for a second communication to the Society.

II. *On the Hatching of Herring Ova in Deep Water.* By J. C. EWART, Esq., M.D., Professor of Natural History, University of Edinburgh.

(Read 16th December 1885.)

The importance of the Scottish Herring Fisheries is so great, that it becomes us as a nation to do our utmost to learn everything that is likely to throw light on the life-history, migration, and other habits of the herring, and to discover, by experiment and otherwise, the best methods of distributing and preserving them when captured.

Hitherto learned societies in this country have not concerned themselves much with the practical application of science, but it seems to me the time has come when science might with great advantage begin to point the more excellent way to those engaged in the ordinary business of every-day life. There is perhaps no industry in which there is more room for improvement than the fishery industry; there is certainly no industry in which Scotland has so much interest as the fishing industry. Notwithstanding this, we are still painfully ignorant of the habits, food, and migrations of most of the food-fishes, and we know still less of the nature of the spawn and of the time of spawning. Further, we have almost everything to learn as to the distribution of fresh fish, and as to the most economical means of preserving those not required for immediate consumption.

During comparatively recent years some striking changes have been effected in the herring fishing. First of all, there has been an immense increase in the "take." In 1810 only 90,000 barrels were cured; in 1820 there were nearly 450,000

barrels. After this comes a period of fluctuation, the take in 1882 being 250,000; in 1830, 450,000; and in 1840, over 650,000. From 1840 to 1874 it varied from 500,000 to 1,000,000 barrels. In 1876 the take was 600,000; in 1878, 900,000; while in 1880 it reached the wonderful total of 1,480,000 barrels, and last autumn's take was nearly as great.

Although there has been an increase in the "take," the rate of increase has not been commensurate with the increase in the amount of netting. Since the introduction of cotton nets and of large herring boats, the means of capture has been increased enormously. An idea of the catching power will be best understood when it is mentioned that the nets in use during the autumn off the Scottish coast would, if fixed end to end, be long enough to stretch three times across the Atlantic.

Another change that has taken place is in the position of the fishing ground. In former years herring approached our shores, and often entered in immense numbers the firths and bays along the east coast. Dr Gordon, in 1852, refers to the Moray Firth shoals congregating on the Guillam bank (which lies near the mouth of the Cromarty Firth), and in earlier times they often penetrated far into the Cromarty Firth.

during the last two years—an enormous number of exceedingly small herring have been captured, not only off the Scottish coast during the autumn, but off the English coast during the winter. Owing to the markets being flooded with large quantities of small, immature fish, the fishery industry has to a great extent been paralysed. The cause of this is undoubtedly largely due to the fishermen using small meshed nets, which, while they fail to "mesh" the large fish, capture large numbers of small, often immature fish that are scarcely fit for food. There is every reason to believe that the present unsatisfactory state of the herring fishery might soon disappear were the fishermen and curers to arrange to use nets with a mesh measuring at least an inch from knot to knot.

A matter of even more vital importance than the size of the fish captured is, will the offshore shoals disappear or diminish (as has been the case with the inshore shoals) if we annually invade them with our large fishing fleets? This will, to a great extent, depend upon whether the herring are able to reproduce themselves without visiting the inshore spawning banks; and granting this to be possible, whether they will select spawning grounds sufficiently near our shores to render their capture a profitable enterprise for our fishermen. That the continued success of the herring fishing, to a great extent, depends on these two conditions, will be at once evident, if we consider under what circumstances the capture of large numbers is rendered possible. It is not sufficient that herring exist in great numbers around the coast; what is necessary is that they should be found in large shoals in certain limited areas. It seems that herring only congregate in large numbers over limited areas during the spawning season. A remarkable fact is that immature as well as mature fish visit the spawning ground. The mature fish, led by their spawning instinct, seek a suitable bank, probably the one where they first saw the light, on which to deposit their eggs; and the immature forms, because of their gregarious or other instincts, follow in their train—the mature fish swimming deeper and deeper as the season advances, while the immature keep near the surface, feeding on Copepods, Thysanopoda, and other minute pelagic forms. This

partly accounts for our fishermen capturing with their small-meshed nets so many small fish.

Whether herring are likely to remain sufficiently near our shores to be within easy reach of the fishermen, or whether they are likely to proceed further and further to sea, we need not discuss at length in the meantime, but it may be pointed out that, if the eggs are capable of hatching in deep water (say in from 60 to 100 fathoms), almost any of the many gravel-coated banks of the North Sea might serve as spawning beds. As is well known, the North Sea is remarkably shallow. If, *e.g.*, we draw a line from Kinnaird's Head to the Naze on the south of Norway, the depth nowhere exceeds 70 fathoms, until we are within some thirty miles off the Norwegian coast. Again we find the 50 fathom-line is about 100 miles from the coast between St Abb's Head and Montrose; while, in order to get 50 fathoms water off Aberdeen, we require to sail eastwards fifty miles. Between Peterhead and Orkney, however, the 50 fathom-line lies from twenty to thirty miles from the coast. As a matter of fact, there is only one small area off the east coast where a depth of 100 fathoms is reached. This area, generally known as the "pot," lies from two to five miles off Fraserburgh, and the greatest depth is 107 fathoms.

Having seen that the North Sea is, generally speaking,

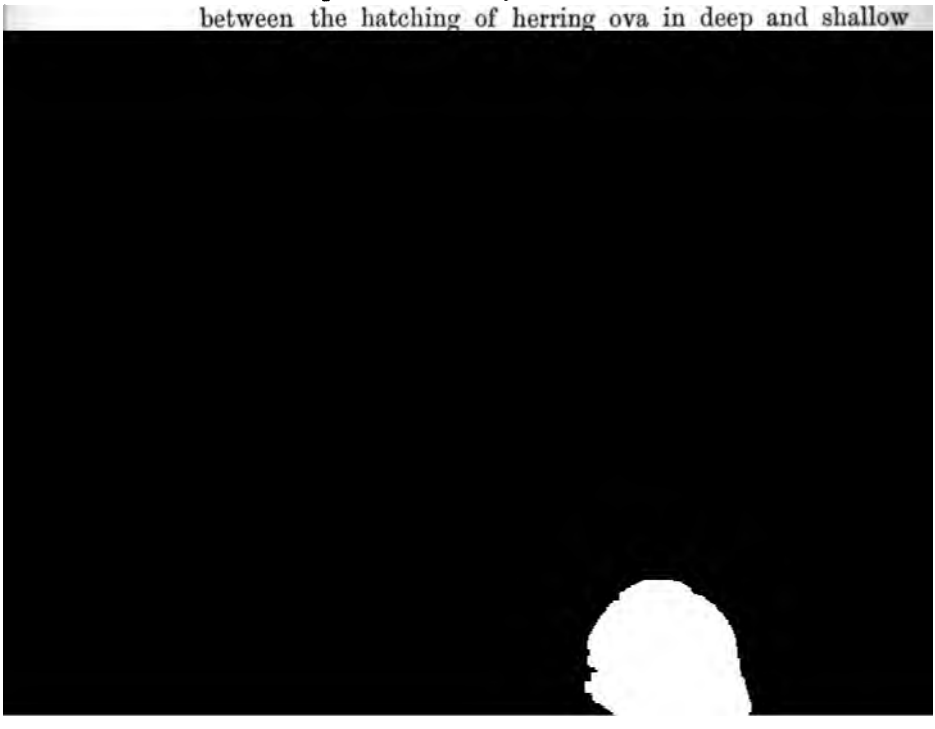
not they would develop in the usual way. An attempt to do this was made in 1884, but without success. In the autumn of 1884 I was unable to join the "Jackal" until the fishing season was nearly at an end. However, after some difficulty, ripe herring were obtained, and the artificially fertilised eggs deposited in the deep water off Fraserburgh in wooden boxes specially constructed for the purpose. Unfortunately, a storm set in the day before it was arranged to haul up the boxes, and although diligent search was made in all directions in the vicinity of the "pot," it was impossible to find any trace of either the buoys or the hatching boxes.

Owing to the Moray Firth being in many respects unsuitable for this experiment, I turned my attention to the west coast, and found a comparatively sheltered spot in Loch Fyne, with a depth of 104 fathoms. To insure success, I had a small tank constructed of thick slate slabs firmly bound together by iron rods. The tank, though only about 20 inches square, weighed nearly 2 cwts. In the top and in two sides of this tank, small windows were made about 6 inches square. Each window was carefully fitted with a teak frame, across which a single layer of horse-hair cloth was stretched. These windows admitted a sufficient current of water to pass through the tank. All the necessary preparations having been made for depositing the tank during last autumn, we were arranging to have eggs conveyed from the east coast, when it was discovered that herring were spawning in Loch Fyne. Mr Brook, who was engaged at the Fishery Board Tarbert Station during the autumn, kindly undertook, in my absence, to obtain eggs and superintend the sinking of the tank in the 100 fathom water. Eggs were obtained on the 11th of September from herring caught in Kilbrannan Sound in water varying from 8 to 12 fathoms. All the eggs were placed at first in the laboratory in water which had an average temperature of 54° Fahr. Some of those that were kept in the laboratory hatched out on the 19th, while others only hatched on the 24th, thirteen days after fertilisation.

On the 16th, one of the glass plates, coated with eggs, was introduced into the slate tank above mentioned, and the tank

was immediately conveyed to the middle of the channel and deposited in 98 fathoms water, about three miles off Tarbert. The tank was lowered by means of a strong manilla rope, to the upper end of which a large cask was attached to serve as a buoy. The surface temperature was 54° Fahr., the bottom temperature was 49° Fahr. The bottom around the tank was chiefly composed of mud. On the 24th—*i.e.*, thirteen days after fertilisation, and eight days after the eggs were deposited in 98 fathoms water—the tank was raised. On examining the glass plate, it was found a number of the eggs in the centre had been destroyed by a fine coating of mud, which had entered through the hair-cloth screen, while those near the margins contained vigorous embryoes almost ready to hatch; in a few cases hatching had taken place. The average bottom temperature while the eggs were deposited was 49·3° Fahr.; the average surface temperature, 54° Fahr., the difference being 4·7°. This is a much smaller difference than was expected, and may be accounted for by warm bottom currents running along the deep narrow channel which extends from opposite Tarbert towards Ardrishaig. The difference of 4·7° during the eight days which the eggs were deposited delayed hatching for about five days.

This experiment clearly shows that the only difference between the hatching of herring ova in deep and shallow



But although it has been proved that herring ova are capable of hatching in deep water, it may be said that the fry would never succeed in finding their way to the surface; and further, that having reached the surface, the food so necessary for the early stages of their existence may not be found forty to sixty miles from shore. First, as to their power of reaching the surface.

In a paper published in the Fishery Board Report for 1883, I mentioned that, "as soon as the fry escaped, they began to ascend by a wriggling motion towards the surface of the water, rising at first only a few inches at a time, to turn and slowly sink head downwards towards the bottom. During the first day they seldom succeeded in rising more than two or three feet from the bottom, and this they only succeeded in accomplishing after many attempts; but on the second day they readily, almost without a single rest, rose three feet at a time; and on the fourth day they succeeded in swimming freely on the surface of the water."

There can be little doubt as to the purpose of this strong instinct to reach the surface; it is to bring them to the strata of water in which there is the largest supply of food. When hatched, the fry have in their yolk-sac sufficient nourishment for several days—the number of days depending on the time required for hatching. Those who have seen the small, almost invisible, newly-hatched herring fry will naturally think 100 fathoms is a long way for them to travel before they reach their food supplies. If, however, the fry are kept under observation, it is found that, after the first day, they can ascend at the rate of a fathom per minute. At this rate they could ascend 100 fathoms in 1 hour 40 min. If we allow for a rest of 30 sec. every three feet for the ascent, we have another hour and 40 sec. to add. Again, if we suppose they sink 30 inches during each rest, we increase the distance to be covered to 150 fathoms; in other words, we add 50 min. to the time required, which gives a total of 4 hours 10 min. for the 100 fathoms. This being the case, we cannot suppose that the fry would have any difficulty in ascending 200 fathoms before the nourishment in the yolk-sac was exhausted.

We are not well acquainted yet with the food of the fry, but there is no doubt about the richness of the surface fauna beyond even the fifty-mile line. The surface fauna of the Moray Firth is extremely rich, and, as I have again and again proved, surface forms are nearly as abundant forty miles at sea as they are inshore.

III. *On the Species of the Genus* Palæoxyris, *Brongniart, occurring in British Carboniferous Rocks.* By Robert Kidston, Esq., F.R.S.E., F.G.S. [Plate I.]

(Read 16th December 1885.)

The genus *Palæoxyris*, one of the most problematical genera of Palæozoic plants, was described by Brongniart in 1828 in his "Essai d'une flore du gres bigarré."[1] It was defined as a terminal fusiform inflorescence, which, with the exception of the stalk-like extension of the fossil, was covered with very regular adpressed rhomboidal imbricating scales.

In the figures which accompany the description of the genus,[2] Brongniart figures certain delicate lines, which appear to arise from the summit of the fossil. These, he thought, might be the remains of the stamens and styles. He also

Morris in 1840 from the coal measures of Coalbrook Dale, as *Carpolithes helicteroides*.[1]

Prof. Morris gives the following description of his fossil: "Fruit ovato-lanceolate, attenuated at both ends; polycarpous (?); carpella, 4 or 5, twisted spirally, but not close together." He further adds: "The apparent resemblance of this specimen to the cast of a fruit of *Helicteres*, has suggested the specific name, although its affinity to that genus may be very doubtful."

"The above name was given to the specimen previously to our having seen a somewhat similar fossil described by Presl in the last part of Sternberg's Flora d. Vorwelt, where it is placed under the genus *Palæoxyris*, Brongniart, from its supposed resemblance to the inflorescence of the recent *Xyris*, an opinion scarcely borne out by the general appearance of this fossil; it has, therefore, been retained under *Carpolithes*, for the reasons stated above."

In 1844, Schimper and Mougeot, in their "Monog. des plantes fossiles du gres Bigarré de la Chaine des Vosges,"[2] still retain *Palæoxyris* among the Monocotyledons, and the same position is accorded to these plants by Unger.[3]

A second Carboniferous species, *P. carbonaria*, Schimper, was described by Stiehler from Wettin in 1850.[4]

Germar in his description of this species, published in 1851,[5] still describes the fossil as covered with rhomboidal scales.

Ettingshausen in 1852 described what he believed to be a new genus of fossil plants from the Wealden of Deister, Germany, which he named *Palæobromelia*.[6] These fossils were of fusiform shape, and composed of a number of seg-

[1] Trans. Geol. Soc., 2d ser., vol. v. Explanation to figs. 12 and 12A, pl. xxxviii.

[2] p. 47. Leipsig.

[3] Synop. plant. foss., p. 168. 1845; and Genera et Species, p. 313. 1850.

[4] Zeitsch. d. deut. geol. Gesell., vol. ii., p. 182, pl. vii. Also in Bull. de la Soc. Géol. de France, 2e sér., vol. vii., p. 650. 1850.

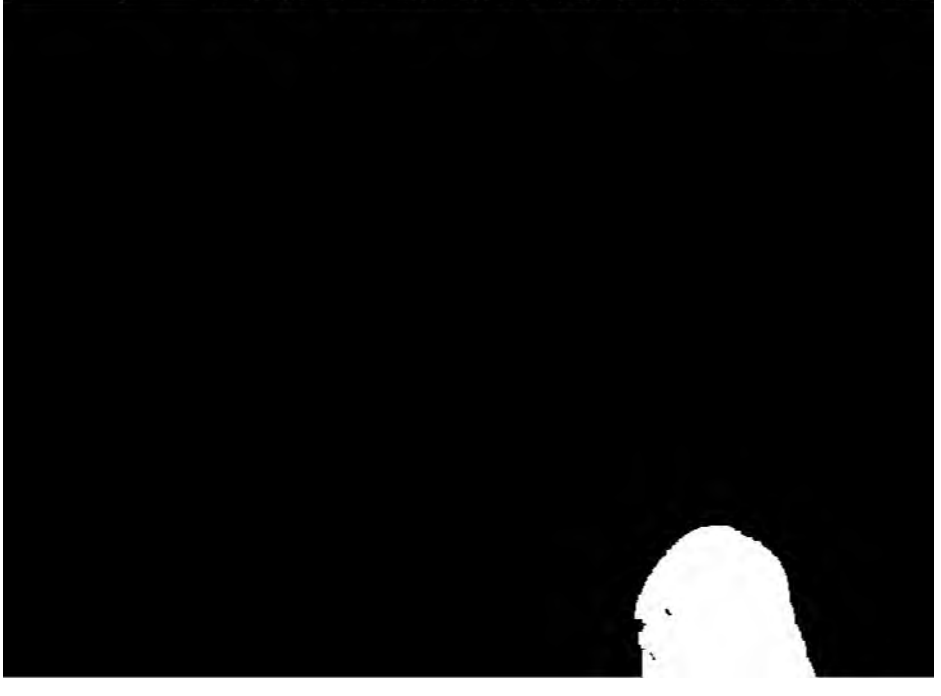
[5] Vers. d. Steinkohlengebirges von Wettin and Löbejin, Heft. vii., p. 95, pl. xxxiii., fig 3.

[6] Uber Palæobromelia, ein neues Fossiles Pflanzengeschlecht, Abhandl. d. k. k. geol. Reichsanstalt, 1 Band, 3 Abth., p. 1. Wien, 1852.

ments twisted in a spiral manner, and he was successful in discovering specimens which showed that these curious plants grew in verticils or umbels.

Palæobromelia was supposed to differ from *Palæoxyris* by the body of the fossils of the former genus being destitute of the scales supposed to occur on the species of *Palæoxyris*. The supposed difference, however, between *Palæobromelia* and *Palæoxyris* is not one of structure, but of preservation,—for in the former had been placed nothing other than uncompressed examples of *Palæoxyris*.

Schimper has pointed out the identity of these two genera,[1] and under the name of *Spirangium*, describes them as composed of several leaves (or carpels ?), which are produced at their base, and united to form a hexagonal petiole, which decreases insensibly towards its lower extremity; above this petiole the leaves (or carpels ?) are twisted in an ascending spiral of 1 or 1½ turns around an axis of apparently little consistency or thickness, on which had, perhaps, been fixed the floral organs or seeds. Above the fusiform swelling, produced by the tortion of these leaves united by their margins, the valves become straightened and prolonged in linear appendages, which are united to form a straight, more or less elongated rostrum, resembling a petiole, free or flexuous. This multivalved capsule, elliptic or fusiform, and



Stiehler, in 1861, proposed the name of *Sporlederia* for the plants included in *Palæoxyris*, Brongniart,[1] as there was no proof that the fossils had any affinity with the recent *Xyris*. He also regarded as distinct from his *Sporlederia* Ettingshausen's *Palæobromelia*, which has been shown to be only an uncompressed condition of *Palæoxyris*.

Schenk was one of the first to seriously question the Monocotyledonous nature of *Palæoxyris*, but he does not venture on any suggestion as to the affinities of these "mysterious plants."[2]

In 1870, Lesquereux noted the discovery of three species of *Palæoxyris* in the Carboniferous rocks of the United States.[3]

To Schimper's remarks on *Palæoxyris*, reference has already been made. This author proposed for these fossils the new generic name of *Spirangium*, as that proposed by Stiehler (*Sporlederia*) had previously been applied to a genus of Mosses. His genus *Spirangium* he places among the "Genera classis incertæ," but he, like most previous writers, regarded these curious fossils as seed-vessels.[4]

More recent writers, including Grand' Eury,[5] Lesquereux,[6] and Renault and Zeiller,[7] have refrained from expressing any opinion as to the affinities of these fossils, nor, after examining many specimens of *Palæoxyris*, can I throw any light on their relationships either to recent or fossil plants. All the specimens which have come under my notice are isolated individuals, and none has shown any attachment to a stem or branch, but twice I have seen two individuals on the same slab, so placed in relation to each other, that one might suppose they diverged from a common point of attach-

[1] Die Bromeliaceen der Vorwelt. Berichte d. natur. Vereines des Harzes zu Blankenburg. Wernigerode, 1861.

[2] Die Fossile Flora des Keupers und Lias Frankens, p. 195. Wiesbaden, 1867.

[3] Report, Geol. Survey of Illinois, vol. iv., p. 464.

[4] Traité d. paléont. végét., vol. ii., p. 514. 1872.

[5] Flore carbonifère du Dép. de la Loire et du centre de la France, p. 307. 1877, Paris.

[6] Coal Flora of Pennsylvania, vol. ii., p. 518. 1880.

[7] Comptes Rendus, 2d June 1884.

ment; that they grew in a verticillate or umbellate manner, has already been shown by Ettingshausen.[1]

It will be seen from what has been already stated, that *Palæoxyris* is generally believed to be a seed-vessel. If, then, these organisms contained seeds or spores (and there is little reason to think that they were attached to its external surface), unless they had been extremely minute, some indication of their presence would surely have been given in the compressed condition, by their imparting a granulation to the outer surface of the fossil, but such an appearance has not, as far as I am aware, ever been observed.

I have examined a few uncompressed individuals. The "segments" in all cases are concave externally, the sutures being raised to form a very slight "collerette," whose presence has already been pointed out by Nathorst in other species.[2]

The chief characters of the species of the genus *Palæoxyris* are derived from the width and number of the spiral segments, and the angle at which they cross the body of the fossil.

Palæoxyris has extended through a long course of time, few genera having the same geological range. Brongniart described *Palæoxyris regularis* from the "Gres bigarré" (Lower Trias), and Lesquereux, *Palæoxyris* (*Spirangium*) *intermedium*, from the sub-conglomerate of Pittston (Lower

may be well to call attention to the closely-allied genus *Fayolia*, described by Renault and Zeiller,[1] from the coal measures of Commentry. This genus is distinguished from *Palæoxyris* by the presence of a very pronounced, either entire or dentate "collerette" on the sutures of the segments. On the spiral segments is also situated, towards their lower margin, a row of short, stiff, spine-like projections. This genus has also been noted by Weiss as occurring at Alben.[2]

Palæoxyris, Brongniart, emend.

Annales des Sciences Naturelles, 1e sér., vol. xv., p. 456. 1828.
Prodrome, pp. 137 and 190. 1828.

Carpolithes, Morris, Trans. Geol. Soc., London, 2d ser., vol. v., p. 489, and Explanation to figures 12 and 12*a*, pl. xxxviii. 1840.

Palæobromelia, Ettingshausen, Abhandl. d. k. k. geol. Reichsanstalt, 1 Band, III. Abth., p. 1. 1852.

Sporlederia, Stiehler, Die Bromeliaceen der Vorwelt. Berichte d. natur. Vereines des Harzes zu Blankenburg. Vernigerode, 1861.

Spirangium, Schimper, Traité d. paléont. végét., vol. ii., p. 514. 1872.

Generic description.—Fossils arranged in an umbellate or verticillate manner around a stem (?) or terminating a common peduncle (?). Each individual of the whorl oblong or fusiform, and composed of spirally contorted concave segments, which at their sutures form a slight collerette. The segments are continued downwards to form a pedicel, and produced upwards into a long beak. When the fossils are compressed, the anterior, crossing obliquely the posterior circumvolutions of the spirally contorted segments, imparts to the surface of the compressed specimen the appearance as of being composed of a number of rhomboidal imbricating scales.

Remarks.—Notwithstanding these fossils have been known for over fifty years, our knowledge of their true nature and affinities still remains a hidden secret. Ettingshausen has figured a group of seven individuals springing from a common

[1] Comptes Rendus, 2d June 1884.

[2] Steinkohlen-Calamarien, pt. ii., pp. 152 and 202 (Abhandl. z. geol. Specialkarte von Preussen u. d. Thuringischen Staaten, Band v., Heft 2. Berlin, 1884.

centre, but whether this common centre is the node of a stem or the termination of a branch, cannot be satisfactorily determined.

In the descriptions of the following species, I have used the term "segment" to denote their component parts, as the words "leaves" or "carpels" convey the notion that the fossils are seed-vessels, an opinion not yet satisfactorily established by proof.

SYNOPSIS OF BRITISH SPECIES.

PALÆOXYRIS HELICTEROIDES, Morris sp.

(Pl. I., Fig. 1.)

Carpolithes helicteroides.

Morris, Trans. Geol. Soc., London, 2d ser., vol. v. Explanation to figs. 12 and 12*a*, pl. xxxviii. 1840.

Bronn, Index palæont, p. 239. 1848.

Goppert and Berger, De fruct. et semin., p. 16. 1848.

Spirangium Prendelii.

Lesquereux (*in part*), Coal Flora of Pennsyl., vol. ii., p. 519, pl. lxxv., fig. 15. 1880.

Schimper, Traité d. paléont. végét., vol. iii., p. 585.

Palæoxyris Prendelii.

Lesquereux (*in part*), Report, Geol. Survey of Illinois, vol. iv., p. 466, pl. xxvii., fig. 10. 1870.

Description.—Body fusiform, 5 or 6 cm. long and 1 cm. or

Horizon.—Coal measures.

Localities.—Coalbrook Dale and Madeley Court, Shropshire; Woodhill Quarry, Kilmaurs, Ayrshire.

Palæoxyris carbonaria, Schimper.

(Pl. I., Figs. 2, 3.)

Palæoxyris carbonaria.

Stiehler, Zeitsch. d. deut. geol. Gesell., vol. ii., p. 182, pl. vii. 1850.

,, Bull. de la Soc. Géol. de France, 2e sér., vol. vii., p. 650. 1850.

Germar, Vers. d. Steinkohlengebirges v. Wettin w. Löbejun, Heft vii., p. 95, pl. xxxiii., fig. 3. 1851.

Andræ, Jahrb. d. Naturw. Vereines. Halle, 1860, p. 130.

Sporlederia carbonaria.

Stiehler, Die Bromeliaceen der Vorwelt. Berichte d. natur. Vereines des Harzes zu Blankenburg, pl. i., 1861.

Spirangium carbonarium.

Schimper, Traité d. paléont. végét., vol. ii., p. 516. 1870-72.

Grand'Eury, Flore carbon. du Dép. de la Loire, p. 307. 1877.

Palæoxyris appendiculata.

Lesquereux, Report, Geol. Survey of Illinois, vol. iv., p. 465, pl. xxvii., fig. 11. 1870.

Lesquereux, Coal Flora of Pennsyl., vol. ii., p. 520, pl. lxxv., fig. 12. 1880.

Spirangium appendiculatum.

Schimper, Traité d. paléont. végét., vol. iii., p. 585. 1874.

Description.—Body fusiform, composed of 6-8 equal segments. The body part of the specimen usually measures about 3 cm. long and 12 mm. wide. The segments are about 2 mm. broad. The fossil is gradually narrowed into a stalk-like extension at each end.

Remarks.—The segments cross the body more obliquely than in any other British species, and when the fossil is compressed, form rhomboidal meshes on its surface, which are as long as broad. The specimen, which is drawn on Pl. I., Fig. 2, shows towards the extremity marked *a* a considerable prolongation of the spirally twisted segments, which, when compressed, owing to the angle at which their circumvolutions cross each other, form much more elongated rhombs than those occurring on the body. The prolongation at the other end of the fossil does not exhibit so great a twisting of the segments. I am unable to say which extremity repre-

sents the base and which the apex of the fossil, but probably that marked *a* represents the basal extremity.

Fig. 3 shows a small portion of an uncompressed example. The segments are concave externally, and the sutures slightly winged. At the part marked *a* (Fig. 3) the impression of the segments of the opposite side is seen. This example shows clearly that when such fossils become compressed the spiral segments of one side crossing obliquely those of the other side must, when flattened, produce on the surface of the fossil a series of rhomboidal markings.

Palæoxyris appendiculata (Lesquereux) appears to be only a somewhat distorted example of *Palæoxyris carbonaria*.

Horizon.—Coal measures.

Localities.—Clays Croft Openwork, Coseley, near Dudley, Staffordshire; Woodhill Quarry, Kilmaurs, Ayrshire.

Palæoxyris Prendelii, Lesquereux.

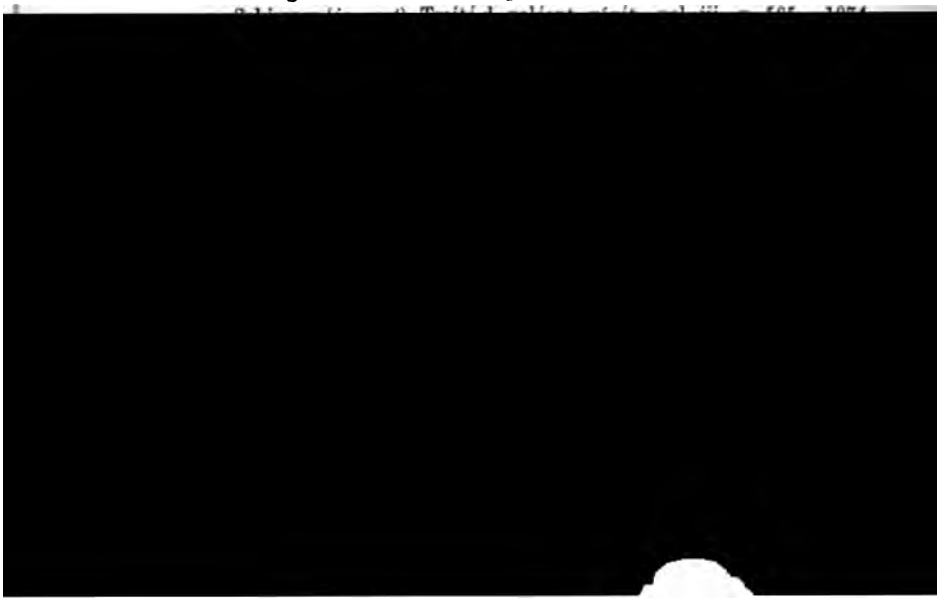
(Pl. I., Figs. 4, 5.)

Palæoxyris Prendelii.

Lesquereux (*in part*), Report, Geol. Survey of Illinois, vol. iv., p. 464, pl. xxvii., fig. 12. 1870. (Excl. fig. 10.)

Spirangium Prendelii.

Lesquereux (*in part*), Coal Flora of Pennsyl., vol. ii., p. 519, pl. lxxv., fig. 13. 1880. (Excl. figs. 14 and 15.)



segments is marked with very fine oblique lines, of which Fig. 5*a* gives an enlarged drawing. These lines, however, may be due to mineralisation. Lesquereux unites with *Palæoxyris Prendelii* his *Palæoxyris corrugata*,[1] but the specimen on which this latter species is founded is badly preserved, and though it probably belongs to *Palæoxyris Prendelii*, its state of preservation is so imperfect that the real characters for specific distinction are entirely obliterated, and nothing further can be said than that the fossil belongs to the genus *Palæoxyris*.

Horizon.—Coal measures.

Locality.—Clays Croft Openwork, Coseley, near Dudley, Staffordshire.

Palæoxyris Johnsoni, n.s.

(Pl. I., Fig. 6.)

Description.—Body broadly fusiform, about 5 cm. long and 1·5 cm. broad; segments about 60 in number, and very narrow, on the centre of the body five segments occupy 3 mm., but at the extremities about ten occupy the same space. The segments are very steep.

Remarks.—This species is easily distinguished from all the others by its numerous very narrow concave segments; the segments decrease in width from the centre of the body towards each end. On the exposed surface marked (*a*) thirty segments can be counted; they here lie almost parallel, and scarcely show any spiral twisting. The specimen is only partially compressed, but on those parts where it has suffered from pressure the rhomboidal markings are about 1 mm. long and slightly less in width; but their size, like that of the segments, decreases from the centre towards the ends.

I have only seen one example of this species, which is in the collection of Mr Henry Johnson, F.G.S., Dudley, after whom I have pleasure in naming it.

Horizon.—Coal measures.

Locality.—Coseley, near Dudley, Staffordshire.

[1] Report, Geol. Survey of Illinois, vol. iv., p. 466, pl. xxvii., fig. 13.

PALÆOXYRIS TRISPIRALIS, n.s.

(Pl. I., Fig. 7.)

Description.—Body fusiform; large; about 12 cm. long and 3 cm. broad. Segments, three; concave, about 9 mm. wide. Sutures slightly raised, but scarcely produced sufficiently to form a distinct "collerette."

Remarks.—This species has a slight resemblance to *Palæoxyris* (*Spirangium*) *multiplicatum*, Lesqx.,[1] from the coal measures of Mazon Creek; but the specimen from which Lesquereux's figure has been taken is so badly preserved that it scarcely affords sufficient data for a comparison, nor does his description of *Palæoxyris multiplicatum* agree with the present species. From the other members of the genus it is easily distinguished by the width of its segments and their small number.

This specimen is also in the collection of Mr H. Johnson, F.G.S., Dudley.

Horizon.—Coal measures.

Locality.—Coseley, near Dudley, Staffordshire.

In conclusion I have only to express my thanks to the Rev. D. Landsborough, Kilmarnock, who kindly afforded me the opportunity of examining and describing the Ayrshire specimens, which are in the possession of their respective

Fig. 5. *Palæoxyris Prendelii.* Uncompressed example from Coseley, near Dudley, in the collection of Mr H. Johnson, Dudley.

Fig. 5*a*. Segment of specimen, Fig. 5, enlarged to show the fine oblique lines.

Fig. 6. *Palæoxyris Johnsoni*, Kidston, n.s. From Coseley, near Dudley. Specimen in the collection of Mr H. Johnson, Dudley.

Fig. 7. *Palæoxyris trispiralis*, Kidston, n.s. From Coseley, near Dudley. Specimen in the collection of Mr H. Johnson, Dudley.

Note.—Except Fig. 5*a*, all the figures are drawn natural size.

IV. *A Synopsis of the British Paguridæ.* By J. R. Henderson, Esq., M.B., F.L.S., Professor of Biology, Christian College, Madras.

(Read 21st April 1886.)

There is perhaps no group of higher Crustacea which has been less studied or more imperfectly characterised in Britain than the Paguridæ or hermit crabs. In support of this statement we need only allude to the fact that most writers of local marine faunas, even up to the present day, are either profoundly ignorant of, or else ignore, the fact that the genus *Pagurus* of older writers was split up more than thirty years ago into a number of separate and distinct genera. Indeed at present only one British species is referable to the restricted genus *Pagurus*, and this, as it so happens, is perhaps the least known member of the group. The examination of dried specimens, a practice more prevalent in former years, has probably proved a frequent source of error.

The modern tendency to multiply genera is well shown in the Paguridæ, and the subdivision of this group has perhaps been carried to an unnecessary degree. It was therefore not without some hesitation that I lately ventured to add a new subgenus to the list.

The present paper, as its title indicates, can only be regarded as a mere synopsis of the British species with some of their chief characters, synonyms, and localities. It was previously my intention to have attempted a complete revision of these, and I had for some time been collecting materials for the purpose, but circumstances have since prevented my carrying out this project.

Family, PAGURIDÆ.

Genus, DIOGENES, Dana.

Dana, U.S. Explor. Exped. Crust., pt. i., p. 438 (1852); Stimpson, Proc. Acad. Nat. Sc. Phil., p. 70 (1858).

Ophthalmic segment furnished with a movable rostriform tooth distinct from the front. Antennal acicle broad at the base, occasionally bifid; the flagellum ciliated. Chelipedes unequal (the left larger), the fingers acuminate. Second and third pair of feet with long dactyli, the fourth pair subcheliform. Abdomen of male without genital appendages.

DIOGENES VARIANS.

Pagurus varians, Costa, Fauna del Regno di Nap. Crust., p. 9, pl. ii., fig. 2 (1838).

Pagurus arenarius, Lucas, Anim. artic. de l'Alg. Crust., p. 33, pl. iii., fig. 7 (1849).

Diogenes arenarius, Stimpson, Proc. Acad. Nat. Sc. Phil., p. 71 (1858).

Diogenes varians, Czerniavsky, Materialia ad Zoograph. ponticam comparatam, p. 127 (1868); Heller, Crust. Südl. Europa, p. 170, taf. v., figs. 13, 14 (1863); Miers, Ann. Mag. Nat. Hist., ser. 5, vol. viii., p. 272 (1881).

? *Pagurus pugilator*, Roux, Crust. de la Méd., pl. xiv., fig. 3 (1830); White, List Crust. Brit. Mus., p. 59 (1847).

Pagurus ponticus, Kessler, Bericht über seine Reise an das Schwarze Meer (1859).

Pagurus Dilwynii, Spence Bate, Ann. Mag. Nat. Hist., p. 320, pl. x., fig.

Hab.—Several localities on the south coast, first found in Britain by Spence Bate at Swansea. It is a common Mediterranean species, occurring also in the Black Sea and Adriatic, and extends from the English Channel to the African coast as far at least as Senegambia. If *D. brevirostris*, Stm., should prove to be merely a synonym of this species, its foreign range extends to the Cape of Good Hope.

Genus, PAGURUS (Fabr.), Dana.

Dana, l.c., p. 449 (1852); Stimpson, l.c., p. 71 (1858).

Front straight towards the middle, ophthalmic segment exposed. Eye-peduncles stout, the basal scales short; antennal acicle short and robust, the flagellum long and naked. Chelipedes rarely subequal, the left usually larger, fingers moving in a vertical plane, slightly excavated inferiorly, and corneous at the tips. Feet of the fourth pair usually chelate. Abdomen of male without genital appendages.

PAGURUS FASCIATUS.

Pagurus fasciatus, Bell, Brit. Crust., p. 375 (1853); White, Pop. Hist. Brit. Crust., p. 76 (1857).

Carapace smooth and even, rounded anteriorly, slightly emarginate posteriorly. Internal antennæ not twice the length of the peduncle of the external; the eye-stalks slightly curved outwards, and as long as the penultimate joint of the external antennæ. Left chelipede large, the hand broadly ovate and smooth, the arm and wrist very short. Right chelipede smaller, but similar to the left. Propodi of the ambulatory limbs ciliated on their lower borders, the fourth pair of legs chelate at their extremities. Body and limbs distinctly marked with alternate bands of red and blue.

This obscure species was described by Professor Bell from a coloured drawing executed by Mr Cocks of Falmouth, and he states that the accuracy of delineation of the latter may be implicitly relied on. If the figure in "British Crustacea" is a correct reproduction, this statement requires modification, as it is there represented with no cervical groove on the

carapace, the antennal peduncles have only two segments and no acicle, and the jointing of the ambulatory limbs is also peculiar. The above characters, taken from the original description, show that the species may be referred to the restricted genus *Pagurus*.

Hab.—Falmouth (Cocks).

Genus, EUPAGURUS, Brandt (*restrictum*).

Brandt, Middendorff's Sibirische Reise, Zool. Thl. i., p. 105 (1851); Stimpson, l.c., p. 74 (1858).

Bernhardus, Dana, l.c., p. 440 (1852).

Front acute towards the middle, ophthalmic segment exposed. External antennæ with a long flagellum, the acicle slender. external maxillipedes rather large. Chelipedes rarely subequal, the right usually larger; the fingers acuminate and with calcareous tips. Fourth pair of legs scarcely subchelate. Abdomen of male without genital appendages.

EUPAGURUS BERNHARDUS.

Cancer Bernhardus, Linné, Syst. Nat. 1049 (1735); Id., Mus. Lud. Ulr. p. 454 (1764); Herbst, Krabben und Krebse, t. ii., p. 14, tab. xxii. fig. 6 (1796).

Astacus Bernhardus, Pennant, Brit. Zool., vol. iv., p. 80, tab. xviii. (1777); De Geer, Mém. pour servir a l'hist. des Insectes, t. vii., p. 408 pl. xxiii., figs. 3-12 (1778).

Pagurus Bernhardus, Olivier, Enc. Méth. Insectes, t. viii., p. 641 (1791)

The rostral projection well marked. Chelipedes tuberculate, with a tendency to become spinose, especially on the inner border of the carpal joints. Ambulatory limbs spiny on the upper borders, the dactyli long and slightly contorted. Length, 4½ inches.

Hab.—British seas everywhere, from between tide-marks down to the greatest depths obtainable; throughout the North Sea, as far north as Finmark (Sars); and the Arctic seas. It is apparently absent from the Mediterranean, but occurs in the Baltic (Möbius). It ranges along the Atlantic shores of North America as far south as Long Island (Stimpson), and occurs also on the Pacific side in Unalaschka and Kamtschatka.

Eupagurus Prideauxii.

Pagurus Prideauxii, Leach, Malac. Brit., tab. xxvi., figs. 5, 6 (1815); Desmarest, Consid. sur les Crust., p. 178 (1825); Latreille, Ency. Méth., pl. cccix., fig. 1 (1825); Milne-Edwards, Ann. des Sc. Nat., 2e sér., t. vi., p. 268 (1836); Id., Hist. Nat. des Crust., t. ii., p. 216 (1837); Lucas, Anim. art. de l'Alg. Crust., p. 28 (1849); Bell, Brit. Crust., p. 175 (1853); White, Pop. Hist. Brit. Crust., p. 75 (1857).

Pagurus Bernhardus, Risso, Crust. de Nice, p. 53 (1816); Costa, Fauna del Regno di Napoli, p. 3 (1845).

Pagurus solitarius, Risso, Hist. Nat. de l'Eur. Mérid., t. v., p. 40 (1826); Roux, Crust. de la Méd., pl. xxxvi. (1828).

Eupagurus Prideauxii, Stimpson, Proc. Acad. Nat. Sc. Phil., p. 75 (1858); Heller, Crust. Südl. Eur., p. 161, taf. v., figs. 1-8 (1863).

The rostral projection not prominent. Chelipedes granulated, the carpal joints tuberculate on their inner margins. Ambulatory limbs almost smooth, the dactyli grooved longitudinally on each side and not contorted. Internal antennæ half as long again as the ocular peduncles. The squame of the external antennæ more slender and less curved than in *E. Bernhardus*. Length, 4 inches.

Hab.—Throughout the British seas in many localities, as far north as the Shetland Islands. It occurs in the Moray Firth (Gordon and Edward), but is apparently absent from the remainder of the east coast of Britain. A shallow-water species, and invariably associated with the anemone *Adamsia palliata* (Bohadsch).

Abroad it ranges from the shores of Norway (Sars and others) to the Cape Verde Islands (Studer). It is a common Mediterranean species, and extends also into the Adriatic Sea.

Eupagurus excavatus.

Cancer excavatus, Herbst, Krabben und Krebse, t. ii., p. 31, tab. xxiii., fig. 8 (1796).

Pagurus angulatus, Risso, Crust. de Nice, p. 58, pl. i., fig. 8 (1816); Id., Hist. Nat. Eur. Mérid., t. v., p. 39 (1826); Desmarest, Consid. sur les Crust., p. 178 (1825); Roux, Crust. de la Méd., pl. xli. (1830); Milne-Edwards, Ann. des Sc. Nat., 2e série, t. vi., p. 268 (1836); Id., Hist. Nat. des Crust., t. ii., p. 217 (1837); Costa, Fauna del Regno di Nap. Crust., p. 7 (1838); Lucas, Crust. in Anim. artic. de l'Alg., p. 28 (1849); Heller, Crust. des Südl. Europa, p. 166 (1863).

Pagurus excavatus, White, List Crust. Brit. Mus., p. 59 (1847).

Eupagurus angulatus, Stimpson, Proc. Acad. Nat. Sc. Phil., p. 75 (1858).

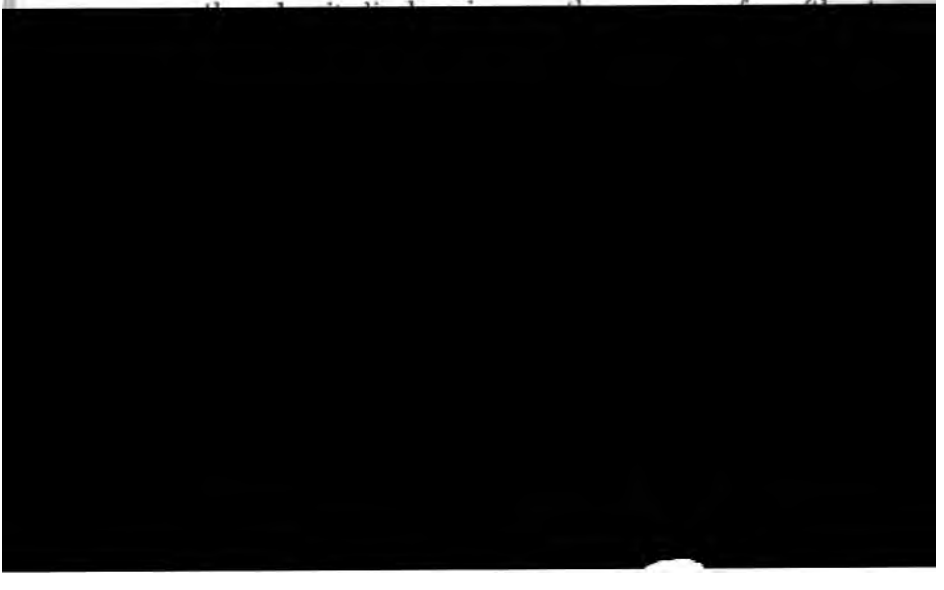
Pagurus tricarinatus, Norman, Brit. Assoc. Rep., p. 264 (1868).

Eupagurus tricarinatus,[1] G. O. Sars, Norske Nordhavs-Exped. Crust., p. 11, pl. i., figs. 8-10 (1885).

Eupagurus excavatus, Miers, Ann. Mag. Nat. Hist., ser. 5, vol. viii., p. 280 (1881).

Pagurus meticulosus,[2] Roux, Crust. de la Méd., pl. xlii. (1830); Milne-Edwards, Ann. des Sc. Nat., 2e série, t. vi., p. 268 (1836); Id., Hist. Nat. des Crust., t. ii., p. 217 (1837); Heller, Crust. des Südl. Europa, p. 167 (1863).

Chelipedes slightly pubescent. Right wrist broad and armed with spiny tubercles, the hand broadly ovate, with



Mediterranean (Roux and others), off the Portuguese coast ("Porcupine"), Bay of Biscay in deep water ("Challenger" and "Travailleur"), St Vincent Harbour, Cape Verdes ("Challenger"), Goree Island, Senegambia (Miers), Norwegian coast (G. O. Sars).

EUPAGURUS PUBESCENS.

Pagurus pubescens, Kröyer, Conspect. Crust. Groenl., Naturh. Tidsskr. ii., p. 251 (1839); Id., in Gaimard, Voyages en Scandinavie, pl. ii., fig. 1 (1849).

Pagurus Thompsoni, Bell, Brit. Crust., p. 372 (1853); White, Pop. Hist. Brit. Crust., p. 78 (1857).

Eupagurus pubescens, Stimpson, Proc. Acad. Nat. Sc. Phil., p. 75 (1858).

Eupagurus Kroyeri,[1] Stimpson, Proc. Acad. Nat. Sc. Phil., p. 75 (1858); Id., Ann. Lyc. Nat. Hist., vol. vii., p. 89 (1859).

Eyestalks reaching the middle of the last joint of the antennular and antennal peduncles respectively. Chelipedes pubescent, armed with tubercles which tend to become spiny. Right chelipede with the wrist equal in length to the hand, and furnished with spines on its inner border. Left chelipede with a central carina extending along the upper surface of the hand. Ambulatory limbs pubescent and spiny. Length, 2 inches.

Hab.—Belfast Bay (Hyndman); Shetland, common (Norman); from Northumberland and Durham to the western limit of the Dogger Bank (Norman); Firth of Forth (Henderson); Firth of Clyde, common (Henderson and others). It is probably common at many points round the Scotch coast.

This species ranges from the British seas to Greenland and Spitzbergen, and is apparently common at considerable depths in the Norwegian fiords (Sars and others). It occurs also along the Atlantic coast of North America, and has been taken in abundance down to depths of 500 fathoms by

[1] I follow the Rev. Dr Norman and others in regarding this a variety of *E. pubescens*, though Prof. S. I. Smith considers it a good species. It only differs from *E. pubescens* in the absence of hairs from the chelipedes and legs, and in possessing a sharper carina on the left hand. The two occur together in many British localities, but the *var. Kroyeri* appears to be more prevalent in deep water.

the U.S. Fish Commission and Coast Survey vessels. Specimens from deep water are usually overgrown by a species of *Epizoanthus.*

EUPAGURUS CUANENSIS.

Pagurus cuanensis, W. Thompson, Brit. Assoc. Rep., p. 267 (1843); Bell, Brit. Crust., p. 178 (1853); White, Pop. Hist. Brit. Crust., p. 75 (1857).

Eupagurus cuanensis, Stimpson, Proc. Acad. Nat. Sc. Phil., p. 75 (1858).

Eyestalks long and slender, slightly exceeding the antennal peduncles, and reaching almost to the end of the antennular peduncles. Chelipedes densely pubescent, armed with spiniform tubercles, which are most prominent on the carpal joints; the wrist shorter than the hand. Ambulatory limbs pubescent. Length, 2 inches.

Hab.—Portaferry and Bangor Bay (Thompson); Belfast Bay (Drummond); Isle of Man (Eyton); Moray Firth (Gordon and Edward); Weymouth (Norman); Shetland, rare (Norman); Firth of Clyde (Norman and others); St Andrews (M'Intosh); Firth of Forth (F. M. Balfour). It is probably not uncommon in suitable localities throughout the British seas.

Abroad this species occurs on the Norwegian and Swedish coasts.

with two irregular depressions. Ambulatory limbs slightly spiny on the anterior borders; the digits pubescent, and furnished with delicate spines.

Hab.—Falmouth (Cocks); Firth of Forth[1] (Howden); off the south coast of Devon and Cornwall, 55 fathoms (Bate and Rowe).

A Mediterranean species extending into the Adriatic.

Genus, SPIROPAGURUS, Stimpson.

Stimpson, Proc. Acad. Nat. Sc. Phil., p. 74 (1858).

Subgenus, ANAPAGURUS, Henderson.

Henderson, Clyde Decapoda, Proc. Glasgow Nat. Hist. Soc. (1885-86).

Carapace depressed in front; the transverse suture very deep. Ocular peduncles short and stout; the corneæ dilated. Chelipedes unequal; the right larger. External antennæ with long and slender flagella, which are usually ciliated; the acicle slender. Ambulatory limbs long and slender. Males furnished with a short curved genital appendage attached to the coxa of the fifth left leg. Females with three modified abdominal limbs on the left side, to which the ova are attached; these are also present, though rudimentary, in the males.

Anapagurus differs from *Spiropagurus* in the form of the male sexual appendage (which is coiled spirally in the latter), and in the unequal chelipedes. In *Spiropagurus*, also, the ambulatory limbs—especially their meral joints—are more robust, and the dactyli are proportionately longer, and ciliated. The external maxillipedes are also much shorter in *Anapagurus*. In the allied *Catapagurus*, A. Milne-Edwards, (= *Hemipagurus*, S. I. Smith), the male appendage is attached to the coxa of the fifth *right* leg.[2]

[1] This locality is, to say the least, suspicious. Perhaps *Eupag. pubescens* var. *Kroyeri*, which is not uncommon in the Firth of Forth, has been mistaken for the present species.

[2] The "Challenger" Collection of Paguridæ contains new species of *Anapagurus* from the Canaries, Cape Verde Islands, Cape of Good Hope, and Port Jackson.

ANAPAGURUS HYNDMANNI.

Pagurus Hyndmanni, W. Thompson, Brit. Assoc. Rep., p. 267 (1843); Bell, Brit. Crust., p. 182 (1853); White, Pop. Hist. Brit. Crust., p. 76 (1857).

Eupagurus Hyndmanni, Stimpson, Proc. Acad. Nat. Sc. Phil., p. 74 (1858).

Anapagurus Hyndmanni, Henderson, Proc. Glasgow Nat. Hist. Soc. (1885-86).

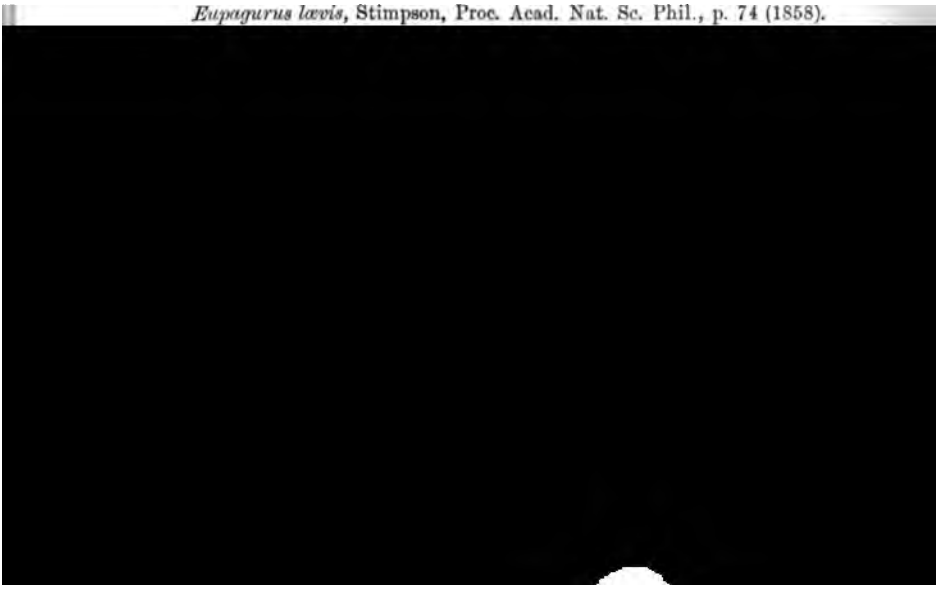
Eyestalks short and thick, not reaching to the ends of the antennal peduncles. Internal antennæ 3-4 times the length of the eyestalks. Chelipedes minutely granulated; the right hand broadly ovate, and finely serrated on the outer border; the wrist spiny on the inner border, and the movable finger with a few small serrations on its outer margin. The ambulatory limbs slender and slighty pubescent. Length, 1 inch.

Hab.—Not uncommon in many British localities. Portaferry (Thompson); Belfast Bay (Drummond); Firth of Forth, common (Howden and others); Shetland, Weymouth, Falmouth, and Firth of Clyde (Norman).

ANAPAGURUS LÆVIS.

Pagurus lævis, W. Thompson, Brit. Assoc. Rep., p. 267 (1843); Bell, Brit. Crust., p. 184 (1853); White, Pop. Hist. Brit. Crust., p. 77 (1857).

Eupagurus lævis, Stimpson, Proc. Acad. Nat. Sc. Phil., p. 74 (1858).



is common, and the specimens unusually fine, we have dredged it at a depth of 105 fathoms.

Abroad it has been taken in the following localities:—Christiansund; Mebotten, 50-60 fathoms (Sars); Mediterranean, in deep water ("Travailleur").

ANAPAGURUS FERRUGINEUS.[1]

Pagurus ferrugineus, Norman, Ann. Mag. Nat. Hist., ser. 3, vol. viii., p. 273; pl. xiii., figs. 1-3 (1861).
Anapagurus ferrugineus, Henderson, Proc. Glasgow Nat. Hist. Soc. (1885-86).

Eyestalks slender, reaching the middle of the last joint of the antennal peduncles; the internal antennæ about three times the length of the ocular peduncles. Chelipedes clothed with silky hairs; the right wrist moderately spiny on the inner margin; the right hand elongato-ovate and smooth, in length equalling the wrist. Left chelipede slender, with the sides nearly parallel. Ambulatory limbs smooth, slightly pubescent. Length, about 1 inch.

Hab.—Sparingly in the following localities:—Moulin Huet Bay, Guernsey; Lamlash Bay, and Shetland (Norman); Moray Firth (Edward); Northumberland Coast (Brady). We have taken it in several localities in the Firth of Clyde.

V. *On Abnormal Limbs of Crustacea.* By Professor DUNS, D.D., F.R.S.E., *Vice-President.* [Plate II.]

(Read 17th March 1886.)

In a short paper read to the Society in April last "On Reproduction of Lost Parts and Abnormality," I referred to examples of these among crustacea. This note is devoted to illustrative instances in the shore crab (*Carcinus mœnas*), the common crab (*Cancer pagurus*), and the Norway lobster (*Nephrops Norvegicus*).

[1] I regret that I have not had an opportunity of examining specimens of the Scandinavian *Pagurus chiroacanthus*, Lilljeborg, with which the present species is perhaps synonymous.

I. CARCINUS MÆNAS.—*a.* (Pl. II., Fig. 1) In the specimens shown I have placed the normal right foot of the anterior pair alongside of the left foot, in which the exaggerated variation and partial distortion occur. In the abnormal form the joints, and especially the so-called arm, wrist, and hand joints, are larger than in the other, while the jointed finger is more slender. The abnormity consists of a pair of pretty tapering, sub-crescent shaped, toothed, yet unjointed fingers springing from the base of the jointed finger of the hand (*chela*). These are little more than $\frac{3}{8}$ths. of an inch long, and a little less wide at the broadest part—the slender points of the crescent being $\frac{2}{8}$ths. of an inch from each other. A furrow, comparatively broad at the arc of the crescent, tapers gradually on both sides, till about a line from the points. The width between the tip of the unjointed finger and the outermost tip of the crescent is $\frac{5}{8}$ths. of an inch. The whole length of the foot is 1 inch and $\frac{3}{8}$ths. (*b.*) The second instance of abnormal growth occurs in the third pair of feet of the same species, but in a larger and older specimen than that just described (Fig. 2). At the tip of the penultimate joint a rounded process, $\frac{3}{8}$ths. of an inch in length, proceeds in the natural direction of the last joint, but instead of tapering to a point, it bifurcates near the tip—the forks showing indistinct traces of toothing. This process is thickest at the base, and to this

forks have been broken at the end. The length of the longest is $\frac{4}{5}$ths. of an inch. The normal forceps remain, but they are shorter, and more slender than usual. Sir John G. Dalyell has figured an abnormal limb having some resemblance to this, but the excrescence is in the direction of the forceps, though separated from them, and has two short processes from the root, which are absent here.[1] (*b.*) The other specimen is interesting as an exceedingly good example either of the restoration of a lost part, or of the repair of an injured claw —most likely the latter, as I conclude from the appearance of the chitinous layer towards the point of the jointed finger, and the deeply uneven surface at the base.

III. Nephrops Norvegicus.—Mr B. N. Peach has kindly given me an excellent example of an abnormal chela in the Norway lobster, accompanied by the following note:—"The specimen was obtained from the Firth of Forth by the late C. W. Peach some years ago. It consists of the last two joints of the large claw from the right side of a Norway lobster. The abnormity consists in the portion of the penultimate joint, which in ordinary specimens opposes the last one, being undeveloped, while the last segment is normal, so that the appearance of an ordinary monodactylous walking limb is assumed." (See Fig. 4.)

Questions of some interest are associated with the phenomena of abnormity in the specimens now described. Do they result from injury to the crust in the stages of its compacting? Or are they the outcome of lesions in the deeper tissue? Does the repair take place before or at and dependent on exuviation? With reference to these questions I notice that while students quote Reaumur, Milne-Edwards, and Bell, the peculiarly interesting and trustworthy observations of Sir John G. Dalyell are seldom noticed, or when his facts are noticed their source is frequently not acknowledged. Sir John refers[2] to one specimen of *Carcinus mænas* which was defective of the right claw; to another which had even lost four limbs and half the forceps of the left claw; and to a third which had been mutilated of the right claw, three

[1] "The Powers of the Creator," vol. i. (supplemental), plate lxx.

[2] *Ibid.*, p. 163.

limbs of the same side, and of a limb on the left side, as all appearing perfect on exuviation. This points to the period of moulting as that at which, in the case of the shore crab, the reproduction of lost parts generally takes place; and, not unlikely, the origin of these abnormal conditions of limbs will be found connected with injuries to the chitinous covering, which is soft and tender at this stage of growth. It is worthy of notice that such injuries occur for the most part at the left side. Of thirty specimens of *Carcinus mœnas* of different sizes, examined by me last August, seven were less or more mutilated on the left side and only one on the right.

VI. *On Whitebait.* By J. C. Ewart, Esq., M.D., Professor of Natural History, University of Edinburgh.

(Read 17th February 1886.)

The question "What are whitebait?" has been again and again asked, but a complete and satisfactory answer has never been given. Since the funeral feast of the founder of the Charter-house in 1612, when six dishes of "whitebait" appeared on the table, the nature of whitebait has been often considered. Yarrell and Valenciennes were inclined to be-

bait consists of about 80 per cent. of herring, and about 20 per cent. of sprats.

In order to extend further this inquiry, with a view to ascertaining whether our own waters might yield what whitebait we require, I have examined samples of the whitebait sent into the London market from the middle of February to the middle of August 1885. During February, 1400 specimens of whitebait were examined, with the result that 93 per cent. were sprats, and 7 per cent. were herring. The sprats varied from 2 to 3 inches in length, while some of the herring were under 2 inches in length, and only partly provided with scales.

During March, 1200 specimens were examined. Of these, 95 per cent. were sprats (from 2 to 2½ inches in length), and 5 per cent. were herring (some of the herring were nearly 4 inches in length).

In April, 800 specimens were examined. Of these 86 per cent. were sprats and 14 per cent. herring. During April the whitebait diminished considerably in size, and the percentage of herring greatly increased. The average size of the sprats was 2 inches, while 12 per cent. of the herring were under 1½ inches in length, and had only the keeled scales developed. The samples at the end of April contained 40 per cent. of only slightly scaled herring, which measured from 1 to 1½ inches in length.

Of the 600 specimens examined in May, 70 per cent. were sprats and 30 per cent. were herring. Most of the sprats were 2¼ inches in length, while 40 per cent. of the herring were about 2 inches in length, and almost completely scaled; the others were from 1½ to 1¾ inches in length, and only partly scaled. At end of the month nearly 85 per cent. of the specimens examined were partly scaled herring.

Eight hundred specimens were examined in June. Of these, 87 per cent. were herring, while 13 per cent. were sprats; 60 per cent. of the herring were from 2 to 2¼ inches in length, and completely scaled, while the remaining 40 per cent. were from 1 to 2 inches in length, and either without scales altogether, or only partly scaled. The sprats varied from 1 to 2¼ inches in length, and the smaller ones

were either without scales, or had only the keeled scales developed.

During July, 600 specimens were examined. Of these, 75 per cent. were herring, and 25 per cent. were sprats; the herring varied from 1½ to 2¼ inches in length, but 80 per cent. were under 2 inches; 8 per cent. of the sprats were under 1¼ inches in length, and were almost destitute of scales.

The August whitebait examined—some 500 specimens—contained 52 per cent. of herring from 2 to 3 inches in length, and 48 per cent. of sprats from 1 to 1½ inches in length. As August advanced, the percentage of small, almost scaleless, sprats greatly increased, until the sprats formed 80 per cent. of the samples examined.

From these specimens examined, it is evident that the nature of whitebait varies considerably. Sometimes it consists almost entirely of sprats, while at other times it consists chiefly of herring; and not only does it vary as to the number of sprats and herring, but also in the size of these fish. In February and March the whitebait in the London market was almost entirely made up of about half-grown sprats. In April the whitebait was smaller, and the number of herring had considerably increased. In May, June, and July the whitebait was almost entirely composed of small fish, many of them with only a few scales, and undoubtedly young

Hitherto our supplies of whitebait have, to a great extent, come from London. While bringing, at a considerable cost, whitebait from London during the winter of 1883-84, we were spreading tons of absolutely fresh whitebait taken from the Forth on our fields, and sending still larger quantities from the Tay to be manufactured into manure at Montrose. From Mr Matthews' inquiries, published in the Fishery Board Report for 1883, it seems, of the 43,000 crans of sprats captured on the east coast during the winter of 1883-84, over 23,000 crans were sold for manure. Of sprats captured in the Tay, 21 per cent. were young herring; but the herring in the Moray and Beauly Firths only formed 8 per cent. of the takes, while the Forth sprats only contained 1 per cent. of herring.

If one-fourth of the sprats had been taken in whitebait nets, we could have sent over 5000 crans of whitebait into the market during the winter of 1883-84. Further, Mr Matthews discovered that there are sprats on the Ayrshire coast, and this discovery I have placed beyond doubt during the present winter. The sprat shoals visit the Ayrshire coast in October; hence we might begin to send whitebait into the market in October, and keep up the supply for four or five months.

While utilising the small fish captured for whitebait, we should certainly either leave the large sprats in the sea (when unable to use them fresh), or preserve them as sardines. Sprats are extensively preserved as sardines in Canada, and I understand we sometimes send consignments of sprats to France, to have them returned to us in tins as sardines. At Eide, on the Hardanger Fjord, there is a large factory for preserving sprats as anchovies. It is to be hoped that in future both the large and small sprats captured may be utilised as food.

I am much indebted to Mr Duncan Matthews for much valuable assistance rendered during this inquiry, especially for assisting in the extremely difficult work of identifying the small scaleless specimens, of which the best whitebait is chiefly composed.

VII. *On the Occurrence of Spores in the Carboniferous Formation of Scotland.* By James Bennie, Esq., of the Geological Survey of Scotland, and Robert Kidston, Esq., F.R.S.E., F.G.S.[1] [Plates III.-VI.]

(Read 21st April 1886.)

The occurrence of spores in coal has been known for many years, though for a considerable time after their discovery they were regarded as sporangia, and it is only within the last few years that their true nature has been understood.

In 1833, Witham, while describing the microscopic structure of coal with the object of proving its vegetable origin, figures in his now classic work on the "Internal Structure of Fossil Vegetables found in the Carboniferous and Oolitic Deposits of Great Britain," several sections of coals from different localities. On his Pl. XI., Figs. 4, 5, he gives a transverse and longitudinal section of "some species of cannel coal from Lancashire." Of this he says:—"I have certainly found traces of organisation" (*l.c.*, p. 50). "The appearances, however, are so undecided, that, although I should be inclined to consider them indicative of a monocotyledonous plant, I shall not venture upon any conjecture

longibracteatus,[1] to which plant the spores he described and figured belonged, "thecæ (= macrospores) reniform, minutely tuberculated. . . ." "The capsules (= macrospores) of this species, neither bituminised nor mineralised, but in a state of brown vegetable matter, are very abundant in some of the coarser sandstones of the Coal Measures."

In 1848, Göppert figures and describes some macrospores under the name of *Carpolithes coniformis*.[2]

C. Feistmantel,[3] though cognisant of the spore nature of *Carpolithes coniformis*, figures and describes under this name masses of macrospores, evidently occurring very much in the same manner as those in many of our coal seams, as at Whitehill Colliery, Rosewell; Tullygarth, Clackmannan; Fordel, Fife; and Kilwinning, Ayrshire, etc.

When thin sections of these spore-coals are examined under the microscope, it is found in almost all cases that the matrix in which the macrospores are embedded is composed in great part of microspores.

Hooker, who was the first to describe the internal structure of *Lepidostrobi*, figures several specimens of these cones showing sporangia containing such microspores. His specimens, however, were very fragmentary, and he was unsuccessful in discovering any portions of *Lepidostrobi* exhibiting macrospores.[4]

The occurrence of macrospores in Lepidodendroid cones was, as already mentioned, observed by Professor Morris in 1840. The next note of a similar discovery is in a paper contributed by Mr Carruthers to the *Geological Magazine* in

[1] Morris in Prestwick, "On the Geology of Coalbrook Dale"—Trans. Geol. Soc. London, 2d ser., vol. v., explanation to Pl. XXXVIII., 1840. *Lepidodendron longibracteatus* is probably referable to *Lep. Sternbergii*, a species that is common in the nodules at Coalbrook Dale.

[2] Preisschrift, Naturkundige Verhandelingen van de Hollandsche Maatschappij der Wetenschappen te Haarlem, Pl. VII., Fig. 17.

[3] Der Hangendflötzzug in Schlan-Rakonitzer Steinkohlenbecken, p. 99, Pl. VI., Fig. 4, 1881 (Archiv. d. Naturw. Landesdurchforschung von Böhmen, IV. Band, Nro. 6, Geologische Abtheil).

[4] Remarks on the Structure and Affinities of some Lepidostrobi—Mem. of the Geol. Survey of Great Britain, vol. ii., part ii., p. 440, Pls. III.-X., 1848.

1865.[1] He here proposes the genus *Flemingites* for the cone he describes. This genus he defines as "*each scale of the cone supporting a double series of roundish sporangia,*" in distinction to the old genus *Lepidostrobus*, which he describes as "*each scale of the cone supporting a single oblong sporangium.*"

The genus *Flemingites* has unfortunately been founded upon an inaccurate conception of the structure of the cone on which it was based—what are regarded by Mr Carruthers as "rounded sporangia" being macrospores (similar in general structure to some about to be described), and not sporangia. His enlarged drawing (*l.c.*, Pl. XII., Fig. A 3) shows between the bracts two rows of the bodies Mr Carruthers describes as sporangia, but which are the macrospores contained in a sporangium attached to the upper surface of the bract. The sporangium wall is not seen in his figure, but has been demonstrated by Binney and others. In fact, the cones subsequently described by Binney in the Palæontographical Society for 1871 as *Lepidostrobus Russellianus*,[2] seem identical with Mr Carruthers' *Flemingites gracilis*. The triradiate ridge on the upper surface of the macrospores is produced by their mutual pressure on each other while contained in the mother-cell, and does not indicate their point of attachment to the bract, as supposed by Mr Carruthers.[3]

Schimper was the first to describe a cone showing both

beautiful example, which he named *Lepidostrobus Dabadianus*, was found in the drift at the entrance of the Valley of Volpe, Haute, Garonne; hence its true geological age cannot be satisfactorily determined.

In the following year (1871) Mr Binney figured a number of *Lepidostrobi*, some of which showed only the sporangia containing macrospores, whilst other more perfect examples showed the upper sporangia to contain microspores and the lower macrospores. Such is the case in his *Lepidostrobus levidensis*, *L. Wunschianus*, and *L. latus*. Mr Binney was therefore the first to note the occurrence of *micro-* and *macrospores* in cones of undoubted carboniferous age.[1]

It is impossible to do more than refer very briefly to the numerous observations on the occurrence of macrospores and microspores, made by Professor Williamson in his various memoirs "On the Organisation of the Fossil Plants of the Coal Measures," where he gives many figures and descriptions of these organisms, either as isolated fossils or as contained in their parent sporangia. It is, however, necessary to refer more particularly to a few forms which are of special interest to us at present.

In the *Phil. Trans.* for 1872 are described some macrospores, of which the peculiarity "is the projection from every part of their external surfaces of numerous caudate appendages, which appear to be actual prolongations of the investing layer of the spore."[2] "These appendages are rather thicker at their bases than nearer their extremities, but the extreme tip of each one is slightly capitate." The structure of these appendages answers exactly to those on some macrospores we describe under the name of *Lagenicula* (Pl. VI., Fig. 20*f-s*).

Other macrospores from Halifax, furnished with fringes of radiating appendages clothing the exterior of the spore, are also described by Professor Williamson. Some of these appendages are simple, others are branched.[3]

[1] Observations on the Structure of Fossil Plants in the Carboniferous Strata, Part ii. Lepidostrobi and some Allied Cones—Palæontographical Soc., 1871.

[2] On the Organisation of the Fossil Plants of the Coal Measures, Part iii., p. 296, Pl. XLIV., Fig. 27ˣ.

[3] Phil. Trans., Part ii., 1878, Pl. XXIII., Figs. 58-60 (Memoir IX.).

A portion of his Memoir X.[1] is also devoted to an examination of fossil spores, some of which are figured. This Memoir also contains a critical examination of the bodies described by Mr Carruthers as *Traquairia*.[2] The result of Professor Williamson's investigation into the nature of *Traquairia* shows that these organisms are Lycopodiaceous macrospores, and not Radiolarians as supposed by Mr Carruthers. These fossils have, therefore, been classed as *Lepidostrobus Traquairia*.

In 1884, Dr Reinsch published a work in two volumes, entitled "Micro-Palæo-Phytologia Formationis Carboniferæ," in which are given over a hundred plates of micro-organisms, the greater portion of which are spores. Of these, however, we must restrict our remarks to those groups only which affect that branch of the subject especially engaging our present attention. Fossil spores are divided by Dr Reinsch into various groups, and of these *Triletes* is the one to which most of our macrospores must be referred.

Triletes, as employed by Dr Reinsch, may be thus defined: More or less triangular, semi-elliptical or circular bodies, usually occurring as compressed discs, outer surface variously ornamented, but always showing three converging ridges.

These spores, though now usually occurring as flattened discs, were, of course, originally more or less globular, the

These are described as "Noncellular (or unicellular?) plants formed of a thallus, distinctly limited, and of definite form. Various forms, up to this time found on organic substances, especially on the largest *Triletes*, are all parasitic, and attach themselves to the organic substratum by their roots developed in a peculiar manner."[1]

"The basal portion is developed into very small and short branches, which, with thickened extremities, end in very small knobs.

"The apical portion is developed in the manner of an elongated filament (*Trichostelium*), or in a flat expansion (*Stichostelium*)."

The two subdivisions are further defined: STELIDEÆ, Subtribus I., *Trichostelium*.

"Thallus filiform, lower part joined to the substratum, and changed into a pedicel of many branches; the upper part variously developed. 1, entire; 2, forked; 3, much ramified, with the ramifications arranged in verticils; 4, much ramified, with the ramification doubly bifurcated without order; 5, ramification irregularly dispersed."[2]

STELIDEÆ, Subtribus II., *Stichostelium*.

"Thallus undivided, entire, sessile, pedicel imperfectly developed."[3]

This group, his *Stelideæ* (containing *Trichostelium* and *Stichostelium*), we regard as an integral part of the spore on which they occur, being in fact merely an extension of the spore wall. This subject will be more fully entered into when describing the macrospores provided with these so-called *Stelideæ*.

There is another point from which some writers have studied the occurrence of fossil spores, viz., the part they take in the formation of coal. In 1857 the late Professor Balfour called attention to the occurrence of numerous spores ("seed-like bodies or sporangia") in Fordel Coal;[4] and Professor Huxley, in his paper "On the Formation of Coal,"[5] ascribes to spores a place of the first importance.

[1] *L.c.*, vol. i., p. 67. [2] *L.c.*, p. 68. [3] *L.c.*, p. 72.

[4] On Certain Organisms found in Coal from Fordel—Trans. Roy. Soc. Edin., vol. xxi., p. 187.

[5] Contemporary Review, 1870, vol. xv., p. 618.

Dawson, on the other hand, in his memoir "On Spore Cases in Coal,"[1] which may be regarded as a reply to the conclusions arrived at by Huxley, believes that it is only under exceptional circumstances that spores enter very largely into the formation of coal.

Though not entering into this part of the subject, we are inclined to accept Dawson's view of the part spores take in the formation of coal. From our experience, when spores occur in any great quantity in coal, they are usually restricted to narrow bands, from an inch to two inches in thickness, and though spores may be detected throughout the whole seam, still the part taken by them in the formation of coal generally (excepting the spore bands already referred to) seems small when compared with the other vegetable remains which enter into its composition.

Such spore bands in coal are, however, common in Scotland.

A paper on the subject by Mr E. Wethered appeared in the *Journ. Roy. Mic. Soc.* for 1885,[2] where figures are given of spore coals from various localities, one plate (Pl. IX.) being devoted to the illustration of the splint coal from Whitehill Colliery, Rosewell, Midlothian.[3]

It next falls to be considered what plants produced these fossil macrospores

described certain cones containing macrospores, which he referred to *Sigillaria*,[1] but, unfortunately, these were not attached to their parent stems, hence their Sigillarian nature was not satisfactorily established.

Subsequently, however, Goldenberg's views were proved to be correct, when in 1884 Zeiller described similar cones to those figured by Goldenberg, still attached to their parent stems, which bore all the characters of the genus *Sigillaria*.[2]

Zeiller figures and describes several *Sigillariostrobus*, some of which contain macrospores with smooth, and others with apiculate, outer surfaces. These two forms are represented by Dawson's *Sporangites glabra* and *S. papillata*.[3] The minute size of the figures given by these authors, prohibits us from identifying any of our forms with theirs, as there occur several varieties of both smooth and apiculate macrospores. It is, therefore, seen that plants belonging both to *Lepidodendron* and *Sigillaria* possess macrospores so similar in size and external structure, that the spores belonging to these two genera cannot be separated from each other when found in an isolated condition.

A good deal of discussion has taken place as to the affinities of *Lepidodendron* and *Sigillaria* with recent genera. That they are both *Lycopodiaceous* seems to us to be clearly established.

Among recent Lycopods, the three genera to which *Lepidodendron* and *Sigillaria* approach most closely are *Lycopodium*, *Selaginella*, and *Isöetis*.

In the first the fructification is *isosporous;* in the two last *heterosporous*, and it is to this latter division that *Lepidodendron*, and most probably *Sigillaria*, belong, though as yet only the macrospores have been observed in *Sigillaria*, —no Sigillarian cone having been discovered which reveals the arrangement and contents of the sporangia of the upper portion where the microspores would most probably occur.

[1] Flora Saræpontana fossilis, Pls. B., Figs. 18-25; IV., Fig. 3; X., Figs. 1, 2.

[2] Ann. d. Scienc. Nat., 6e sér., Tome xix., p. 256, Pls. XI., XII.

[3] Quart. Journ. Geol. Soc., vol. xxii., p. 165, Pl. XII., Figs. 80, 81; also Acadian Geol., 1868, p. 491.

Lepidodendra, in their fructification, approach most closely to *Selaginella*, the cones of which, as well as those of *Lepidodendron*, contain both micro- and macrospores, the latter usually occupying the lower, and the former the upper sporangia.[1]

Sigillaria, on the other hand, has been referred to *Isöetes*;[2] but it appears to us that a more satisfactory position is that accorded it by Zeiller, viz., an intermediate place between *Lepidodendron* and *Isöctes*.[3] To *Isöctes*, *Sigillaria* appears to be related by the arrangement of the sporangia, and perhaps through its mode of disseminating the spores; to *Lepidodendron* by the structure of the leaf-scars and the internal anatomy of its stem.[4]

The gigantic size of the macrospores of fossil Lycopods has led several botanists to regard them as sporangia. When examined as transparent objects, they are found to be composed of a single cell, whose wall seems to consist of two layers. In many cases the outer layer of the spore wall (the *exosporium*) separates from the inner layer (the *endosporium*), and in this condition their microscopical examination is easily accomplished.

Had these fossils ever possessed a cellular structure, traces of it would still be preserved; for associated with the macrospores are numerous films of epidermal tissue, showing most

Zeiller examined, as transparent objects, some of these bodies from his Sigillarian cones, and came to the conclusion that they were single cells, or, in other words, *spores*, and not *sporangia*. But, independently of this microscopical evidence in favour of the sporal nature of these fossils, there is the further evidence of their having been found *in situ* in sporangia, as figured by Binney, Williamson, and others.

In *Selaginella* the spore wall also most commonly consists of two parts—the *endosporium* and *exosporium*. According to Hoffmeister, both layers take part in the composition of the long spines which adorn the outer surface of the macrospores of some species. These spines on quite ripe spores appear considerably shorter than when the spores are half-developed, as the pressure which the rapidly-growing spores exert upon one another breaks off the point of the spines.[1]

In recent Lycopods the spores are usually developed in groups of four; the macrospores of *Selaginella* affording good examples of this.

When examining the fossil macrospores in connection with this paper, we have frequently found them occurring still united in groups of fours (*see* Pl. IV., Figs. 16*d*, 16*e*), and in a few cases have found the four macrospores still contained within a sporangium, which has been removed from its bract.

The recent macrospores develop a small *prothallus*, which is exposed at maturity by their bursting along the three converging ridges; and we have found some of the fossil macrospores split in a similar manner, suggesting that the *prothallus* of these individuals had arrived at a certain state of development before fossilisation took place. Some such specimens are figured on Pl. III., Figs. 6*a*, 7*a*.

The fossil macrospores vary in external colour from black to fawn, the latter colour depending on the extent to which they have been weathered. The blackness of the spores appears, however, to be usually the result of staining; for the spores, when broken or ground for microscopical examination, always exhibit a brown or amber-coloured cell wall. This is especially observable when sections of spore coal are examined.

[1] Hoffmeister, On the Germination, Development, and Fructification of the Higher Cryptogamia, translated by Fred. Currey, 1872, p. 388.

The macrospores of a number of recent Lycopods have been examined for the purpose of comparison, and though as a rule these are much smaller than those of *Lepidodendra* and *Sigillariæ*, their similarity to them is interesting and striking. A few are figured on Pl. VI., Figs. 21-25.

The fossil macrospores are divisible from external characters into three groups:— 1, *smooth*; 2, *apiculate*; and 3, those with an *equatorial zone*. Among recent Lycopods, spores occur answering to these three divisions.

In our investigations we have collected material for examination from the four divisions of the Carboniferous Formation as developed in Scotland, and in all—from the basement beds of the Calciferous Sandstones to the uppermost beds of the Coal Measures—spores have been plentifully found.[1]

The most suitable situations for collecting are outcrops or exposed sections afforded by streams, sections on the seashore, or exposures formed by railway cuttings, etc., where the strata have become somewhat *weathered*. In such situations few of the impure coals or bituminous shales have failed to yield spores or other organic remains. Such weathered material, if free from bitumen, is easily prepared, requiring merely to be first *thoroughly* dried, and then steeped or boiled in water; this usually reduces it to mud.

Shales or fireclays highly charged with bitumen do not

usually contains most of the spores. It should then be dried, and searched under a lens. The spores are easily lifted from the mass with a camel-hair brush, slightly moistened by being drawn between the lips.

The fine dust which passed through the first sieve must not be thrown away, but allowed to settle, and then examined under the microscope for *microspores* or other minute organisms. Any organisms it contains worth permanent preservation may be mounted with Canada Balsam.

LIST OF LOCALITIES FROM WHICH SPECIMENS HAVE BEEN COLLECTED, WITH THE FORMS OF MACROSPORES CONTAINED IN EACH.

1. Shore, half a mile east of Cove Harbour, one and a-half miles N.E. of Cockburnspath, Berwickshire.

Position.—Basement beds of the Calciferous Sandstones. In sandy fakes beneath a hard sandstone in which *Stigmariæ*, *Lepidodendra*, and Calamite-like plants in fragments are abundant.

In the spore bed scorpion remains are frequent, and in the plant bed the original of the Eurypterid, *Glyptoscorpius* (*Cycadites*) *Caledonicus*, was found.

It is noteworthy that in the Upper Old Red Sandstone, which occurs only a few feet below, few, if any, plants are preserved; yet here all at once spores are found in the sandy fakes in myriads, proving the existence of an abundant vegetation little younger in age than that of the underlying Old Red Sandstone.

Contents.—LAGENICULA I.

In fine state of preservation.

2. Old quarry north side of Colinton Road, under Craiglockhart Hill, three miles west of Edinburgh.

Position.—Calciferous Sandstone Series near the base of the Wardie Shales. In fireclay beneath a shale-like coal.

Contents.—LAGENICULA I.

Specimens only fairly preserved.

3. Shore west side of Billow Ness. First and second coals west of the Ness, one mile west of Anstruther.

Position.—Calciferous Sandstone Series, about 3000 feet below Carboniferous Limestone Series.[1]

Contents.—LAGENICULA I.

Specimens well preserved.

4. Shore half-way between Roome Rocks and Kilminning Castle, Fife.

Position.—Calciferous Sandstone Series. Exact position uncertain. In shale and fireclay connected with several thin coals.

Contents.—LAGENICULA I.

Specimens well preserved.

5. Railway cutting, Priory Moor, west of road to Anstruther, three miles south-east of St Andrews.

Position.—Calciferous Sandstone Series. Exact position uncertain.

Contents.—LAGENICULA I.

6. Shore above trap dyke, one mile east of Rock-and-Spindle, four miles east of St Andrews.

Position.—Calciferous Sandstone Series. Exact position uncertain. In fireclay below small coal.

Contents.—LAGENICULA I.

Specimens well preserved.

nite Bed, 2280 feet below Carboniferous Limestone Series. In shale-like coal, one foot in thickness.

Contents.—LAGENICULA I., and *var.*
„ II.
Specimens well preserved.

9. In south-east corner of the cliff under the Castle of St Andrews.

Position.—Calciferous Sandstone Series. Two hundred feet above Encrinite Bed. In black shale full of reed-like plant remains. Bed four inches in thickness, resting on fireclay.

Contents.—LAGENICULA I.
Specimens well preserved.

10. Nydie Quarry, Knockhill, four miles west of St Andrews.

Position.—Calciferous Sandstone Series. About 200 feet above Encrinite Bed. In good coal one foot in thickness, above a shelly sandstone which overlies Myalina Shale and Limestone.

Contents.—TRILETES III.
Specimens very well preserved.

11. Shore under Coalfarm, one mile east of St Monans.

Position.—Carboniferous Limestone Series, eight or ten feet below 2d Limestone (Hosie) of the Carboniferous Limestone Series. In shale-like coal.

Contents.—TRILETES II.
„ XIII.
„ XVI. (?)
LAGENICULA I.
Specimens well preserved.

12. Railway cutting at Crossgatehall, three miles south-east of Musselburgh.

Position.—Carboniferous Limestone Series. Fireclay under coal below the 3d Limestone of Carboniferous Limestone Series.

Contents.—LAGENICULA I.

13. Cliff on left bank of Bilston Burn, below Pathhead Farm, one mile south-west of Loanhead, Midlothian.

Position.—Carboniferous Limestone Series, a few feet above the 3d Limestone of the Carboniferous Limestone Series.

Contents.—TRILETES XVI.

GROUPED SPORES (? *Triletes* XVI.).

Specimens well preserved.

14. Shore east of Seafield Tower, one mile south-west of Kirkcaldy.

Position.—Carboniferous Limestone Series. Fireclay below coal beneath the Tyrie Limestones, the 3d Limestone of the Carboniferous Limestone Series.

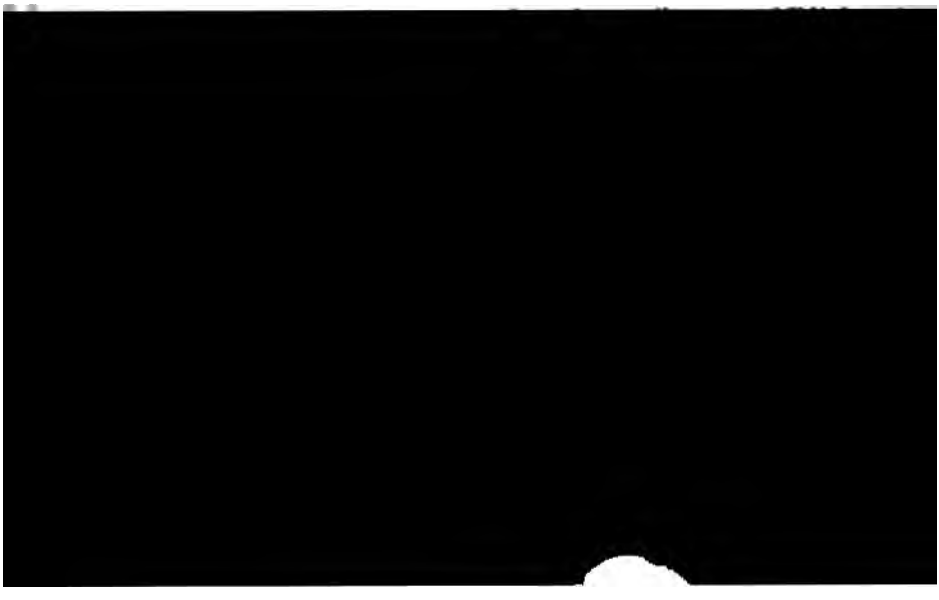
Contents.—LAGENICULA I.

15. Joppa Quarry, three miles east of Edinburgh.

Position.—Carboniferous Limestone Series. Fireclay three inches below small coal (three inches), one foot beneath Joppa Limestone (the No. 4 Limestone of the Geological Survey = the Index or Cowglen Limestone of the western coalfields).

Contents.—LAGENICULA I.

Specimens well preserved.



18. Shore under Old Doocot, about 200 yards east of Ravenscraig Castle, one mile east of Kirkcaldy.

Position.—Carboniferous Limestone Series. About half-way between Ravenscraig (Gair) and Carberry (Levenseat) Limestones, the two highest limestones of the Carboniferous Limestone Series. In shale-like coal.

Contents.—LAGENICULA I.

19. Shore under Old Doocot, about 200 yards east of Ravenscraig Castle, one mile east of Kirkcaldy.

Position.—Same as No. 18. In coal above Doocot Coal.

Contents.—LAGENICULA I.

„ II.

The latter form is rare. Specimens well preserved.

20. Suburban Railway, Niddrie Section, three miles south-east of Edinburgh.

Position.—Carboniferous Limestone Series. Coal half-way between No. 5 and No. 6 Limestones of the Geological Survey.

Contents.—LAGENICULA I.

21. Left bank of the Avon below Linlithgow Bridge, one mile west of Linlithgow.

Position.—Carboniferous Limestone Series. Fireclay under small coal (two inches) below Dykeneuk (or Gair) Limestone, one of the Upper Limestones.

Contents.—LAGENICULA I.

„ I. *var.*

Specimens are in a fine state of preservation, and show well the spinous appendages. Only one example of the *variety* was found.

22. Left bank of Avon opposite Littlemill, two miles north-west of Linlithgow.

Position.—Carboniferous Limestone Series. Small coal and fireclay below the Dykeneuk (or Gair) Limestone, one of the Upper Limestones.

Contents.—LAGENICULA I.

Specimens well preserved, and very plentiful

23. Suburban Railway, Niddrie section, three miles south-east of Edinburgh.

Position.—Millstone Grit, about sixty feet above the No. Limestone of the Geological Survey (Levenseat or Carberry the highest limestone of the Carboniferous Limestone Series In fireclay below four-inch coal, and above eight inches of sandstone permeated with Stigmarian rootlets, proving it ha been an old soil.

Contents.—TRILETES V.
„ VI.
„ IX.
„ XII.
„ XV.

Only one specimen of *Triletes* VI. was found. *Triletes* V was common, and finely preserved. *Triletes* XII. and IX were rare. The specimens in this gathering are, as a rule beautifully preserved.

24. Shore a few yards west of Joppa Salt Pans, three miles east of Edinburgh.

Position.—Millstone Grit, basement beds. Two small coals in bed of thick white fireclay.

Contents.—TRILETES VI.
„ VII.

Position.—Millstone Grit, near middle. In fireclay under two small coals, four or five feet apart.

Contents.—TRILETES VII.
„ IX.
„ XII.
„ XIV.

The spores from this locality are in an excellent state of preservation. *Triletes* XIV. is one of the commonest forms, and shows the equatorial zone in a very perfect manner.

27. Shore, Cliff under Francis Pit, one mile east of Dysart.

Position.—Coal Measures. In two thin coals in fireclay a few feet apart. The same beds are also seen on the shore between tide marks.

Contents.—TRILETES I.
„ IX.

Triletes IX. is rare; I. very plentiful. Specimens beautifully preserved.

28. Shore west side of Blairpoint, one mile east of Dysart, Fife.

Position.—Coal Measures. In shale with streaks of coal, *Lepidodendra, Sigillariæ,* a few ferns, etc.

Contents.—TRILETES I.
LAGENICULA II.

Triletes I. very plentiful. Specimens in a fine state of preservation.

29. Broomieknowe Railway Cutting, east end of station platform, half a mile east of Lasswade.

Position.—Coal Measures. In the bottom of the splint coal of Whitehill, Eldendean, and other collieries in Midlothian. Coal weathered at outcrop.

Contents.—TRILETES I.
„ IX.
„ XI.
„ XVII.

This is a very good gathering. The spores are more or less bleached through weathering, though not at all destroyed. The spines of the apiculated forms retain their dark colour upon the light fawn-coloured outer surface of the spore wall,

thus forming very beautiful microscopical objects. *Triletes* I. is not common; some specimens of *Triletes* XVII. occu still united in groups of four, as well as in a separated condition.

30. Broomieknowe Railway Cutting, east side of statio house, half a mile east of Lasswade.

Position.—Coal Measures. Top of first coal below splin coal. Coal weathered at outcrop.

Contents.—TRILETES X.

Specimens bleached and well preserved, like those o *Locality* 29.

31. Broomieknowe Railway Cutting, west side of statio house, half a mile east of Lasswade.

Position.—Coal Measures. In rough coal above "parro coal." Weathered at outcrop.

Contents.—TRILETES X.

„ XI.

Spores bleached and preserved as mentioned in *Locality* 29 This is also a good gathering.

32. Broomieknowe Railway Cutting between station an bridge, half a mile east of Lasswade.

Position.—Jewell Coal, weathered at outcrop.

Contents.—TRILETES VI.

viduals of the same form appear to be enveloped in their sporangia.

34. Broomieknowe Railway Cutting, cliff at tunnel 100 yards west of station, half a mile east of Lasswade.

Position.—Coal Measures. About 120 feet below Jewell Coal. In the bottom part of a small coal (one foot thick) in the middle of the section.

Contents.—TRILETES I.
„ II. and II. *var.*
„ VII.
„ IX.
„ X.
„ XI.

Specimens are very well preserved. Of *Triletes* II. *var.* and *Triletes* IX. only one of each was observed.

35. Kelly Burn, one mile east of Dollar. In the outcrops of several thin beds of shale.

Position.—Coal Measures.

Contents.—TRILETES I.
„ II.
„ VII.
„ VIII.
„ IX.
„ X.
„ XII.
„ XIV.
„ XVIII.

Specimens well preserved. *Triletes* I. and XIV. very common; II. more rare; VII. plentiful; VIII., IX., X., and XII. rare; XVIII. also not very common.

36. *Débris*, Tullygarth Pit, Clackmannan.

Position.—Coal Measures.

Contents.—TRILETES VII.
„ XIV.

37. Hailes Sandstone Quarry, four miles west of Edinburgh.

Position.—Calciferous Sandstone Series, near the Ward Shales.

Contents.—LAGENICULA I.[1]

NATURE AND CONDITION OF THE BEDS FROM WHICH TH SPORES HAVE BEEN COLLECTED.

I. COALS.—The Splint and Parrot Coals (if not the only are the chief kinds which have yielded spores.

The Soft or Cherry Coals in which the process of bituminisa tion has been carried to any considerable extent, cannot b expected to yield well-preserved spores, as, being thoroughl mineralised, the vegetable tissue of which they are compose has been converted into a pure amorphous bitumen or carbo Splint coals being chiefly composed of compressed vegetab tissue, are the chief spore-yielding coals; while Parrot Coal consisting largely of mud or clay, highly charged with liqui bitumen or comminuted carbon, have also yielded spores i considerable numbers. When either of these coals is *fres* great difficulty is experienced in extracting the spores, th cohesion of the mass being so great, that the spores can onl be liberated by mechanical means, such as crushing sma splinters with pincers, or striking them smartly edgewi with a hammer. In these cases the yield is, however, small, that little success has attended this mode of procuri

profusely. Generally, the first two or three inches of fireclay beneath the superincumbent coal is the most prolific. This is well illustrated at the two following localities. The first is the locality we originally examined for spores, and is situated just under the Railway Weigh-house of the Niddrie Section of the Edinburgh Suburban Railway. The lowest bed is a sandstone eight inches in thickness, permeated with Stigmarian rootlets: above this is a fireclay six inches thick, of which the lower two inches were barren, while the upper four inches contained great quantities of spores. The coal above the fireclay, which was four inches thick, yielded only a few spores.

In the second instance, which was that of the fireclay immediately under the coal beneath the limestone of Joppa Quarry, spores were only found in the first three inches, whilst the lower three inches were barren. The sandstone underlying the fireclay also contained many Stigmarian roots and rootlets.

III. Bituminous Shales or Shale-like Coals.—These may be considered poor or imperfect coals, composed of clay or shale highly charged with bitumen or other form of hydrocarbon. Where the process of bituminisation has been arrested by the quantity of clay in the bed, the bitumen has preserved the spores from decay by eremacausis, and they are "mummified" or "embalmed" by its black oil. These shale-like coals, when weathered, can be easily crushed, and the spores liberated.

IV. Plant Beds (such as at Blairpoint).—In such beds where there is scarcely any formation of coal, and only a blackening of the shale, with perhaps occasionally a few thin streaks of coal, the shale readily yields to the process of artificial weathering, which consists in simply drying the shale and steeping it in water, when it divides into small pieces, or is reduced to a clay. The spores can then be easily washed and floated off.

Black Fakes in Sandstone Beds.—At several places on the shore at Joppa, and in Joppa Quarry, but especially in Hailes Quarry, parts of the sandstone are divided into thin *laminæ* of black carbonaceous matter and white sandstone.

These black fakes, when crushed and washed, resolve themselves into vegetable *débris*, consisting of carbonised wood compressed stems of plants, large oblong or lanceolate sacs flattened into mere films, and a few spores. They also contain a considerable number of pieces of Scorpion and Eurypterid skin.

At Hailes Quarry the whole 200 or 300 feet of sandstone is divided into thin beds by the partings of clay or black films of carbonaceous matter; and sometimes these layers are made up entirely of alternations of black and white fakes only a line or two in thickness. These black fakes being composed of vegetable *débris*, the sandstone of Hailes Quarry must represent a long period of deposition of sand in some quiet lake, into which the winds and streams frequently carried the lighter vegetation of the land, which was deposited as drift wrack along with the falling sediment.

Incidental Organic Contents.—Besides *macrospores* and *microspores*, many other organisms were discovered while examining shales and coals. The most numerous were of vegetable nature. Pinnules of ferns frequently occurred completely "mummified"—that is, with the ordinary blackness bleached from them, simply leaving a colourless or light brown tissue, in which occasionally the cell structure is preserved. Sometimes portions of fern fronds in circinate verna

Some of the thin coals were almost entirely composed of such carbonised vegetable matter.

Numerous evidences of animal life are present. These consist of fragments of Scorpion skin, which occur in almost every old soil or weathered coal. They are generally very fragmentary, but some specimens are sufficiently well preserved for Mr B. N. Peach to determine to which portion of the body they belong. These fragments are frequently dotted with hair-like projections of the skin, similar to those on recent scorpions, and in many of the examples pores were numerous. These specimens are of a rich reddish-brown colour, and highly-enamelled, with a polished surface.

It is difficult to realise the thought suggested by these fragments of Scorpion skin, that in Midlothian a climate once prevailed in which a wholly tropical Scorpion, or a closely-allied form, abounded in great numbers. The preservation of these fragments seems due to the almost indestructible substance of which they are composed, the chitine being proof against all the ordinary agencies of decay.

In many of the old soils, fragments of Eurypterid skin in a perfect state of preservation, with all the peculiar surface ornamentation of the family, also occur. The Eurypterid skin is universally of a dark plum-blue or an intense black, very dense in substance, about the thickness of ordinary writing-paper, always opaque, and quite unlike the scorpion skin, which is generally translucent, and sometimes transparent. These fragments of Eurypterids were exceedingly welcome, as they proved that the Eurypterids of the Carboniferous Period were not aquatic, but land animals, thus confirming the conclusions at which Mr Peach had previously arrived.[1]

In Joppa Quarry, in two positions—one immediately beneath the limestone, and another about 100 feet higher in the section, in two fireclays, two or three inches in thickness, each under a small coal, and therefore land surfaces—several hundreds of fragments of Eurypterids were found. Such

[1] Trans. Roy. Soc. Edin., vol. xxx., p. 511.

occurrences demonstrate that these animals lived and die on land, and not in water.[1]

Description of Specimens.

Triletes, Reinsch.

Triletæ, Reinsch, Micro-Palæo-Phytologia Formationis Carboniferæ, vol. i. p. 1, 1884.

Stelideæ (including Sub-Tribes *Trichostelium* and *Stichostelium*), *Ibid.*, p. 67.

Division I.—Lævigati.

The outer surface of the macrospores of this division is smooth—some having a polished appearance, others a very slight granulation, though this is not quite so strongly marked as on the surface of the spores of *Selaginella Martensii*, Spring (Pl. VI., Fig. 23), whose outer surface has a great similarity to that of some of the fossils included in this division.

[1] As the circumstances which led to the search for spores are not only interesting, but instructive, they may be briefly related here.

Incidentally the examination of the section at Niddrie, on the new Edinburgh Suburban Railway, led directly to the discovery of beds of coal and fireclay from which spores could be got free in great numbers. In the extreme east of this cutting the solid rocks give place to a thick bed of drift, consisting of two beds of boulder clay—a lower and an upper—separated by eight or ten

TRILETES I. Pl. III., Figs. 1*a* and 1*b*.

Macrospore large, outer surface of glossy smoothness. Triradiate ridge occupying two-thirds of the upper surface, the extremities of the arms of which are connected by a more or less clearly defined semicircular ridge which divides the central portion of the spore into three depressed areas, each bounded by two straight lines and a curved one. A few short wrinkles generally radiate from the centre.

Average size.—1·65 mm.

Horizon.—Coal Measures.

Localities.—27, 28, 29, 34, 35.

TRILETES II. Pl. III., Figs. 2*a*, 2*b*, and 2*c*.

This form has the general character of *Triletes* I., but is smaller, and appears to have been stouter. The triradiate ridge also occupies rather more than two-thirds of the upper surface.

The *var.* A (Pl. III., Fig. 2*b*), from *Loc.* 11, has a much stronger triradiate ridge, and may belong to a plant specifically distinct from that which bore the type form of *Triletes* II.

A curious variety is given at Fig. 2*c*, where between the diverging ridges three or four small oval pit-like hollows occur.

Average size.—1·25 mm.

Horizons.—Coal Measures (Figs. 2*a* and 2*c*), and Carboniferous Limestone Series (Fig. 2*b*).

Localities.—11 (Fig. 2*b*), 34 (Figs. 2*a*, 2*c*), 35.

to be full of spores of the same kinds and in the same condition as those from the lumps of mud on the top of the sand-bed in the boulder clay.

Following up the clue which circumstances had thus given, all the likely fireclays and coals in the Niddrie cutting were examined for spores, as also the same rocks on the shore at Joppa and on the Fife coast at Dysart, with the result that spores were found in a greater or less degree in all. The poor coals and shales of the calciferous sandstones, and the richer coals and shales of the Coal Measures, were next examined; and though spores were not universally found, they were found in so many, that it may be concluded that almost every coal or fireclay and many plant-beds have spores embedded in them in such a way that they can be easily separated from the matrix by the methods described in this paper (p. 92).

TRILETES III. Pl. III., Fig. 3.

Macrospore smooth, but not having a bright polished surface as on I. and II.; triradiate ridges very prominent and short, and occupying only one-third of the upper surface. A curved ridge connects the extremities of the arms of the diverging ridges, but is not so much elevated as the triradiate ridge itself. Occasionally a few feebly indicated ridges radiate from the centre.

Size.—1·80 mm. to 1·42 mm.

Horizon.—Calciferous Sandstone Series.

Locality.—10.

TRILETES IV. Pl. III., Figs. 4*a*, 4*b*.

Macrospore very small, outer surface feebly granulated. Triradiate ridge prominent, occupying about four-fifths of the upper surface, between the arms of which are radiating flexuous lines that usually extend to the curved line that connects the arms of the central three-rayed star. This is the smallest fossil macrospore with which we have met.

Size.—0·57 mm. to 0·51 mm.

Horizon.—Calciferous Sandstone Series.

Locality.—7.

Division II. APICULATI

Size.—2 mm. to 1·50 mm.
Horizon.—Millstone Grit.
Locality.—23.

TRILETES VI. Pl. III., Figs. 6*a*, 6*b*, 6*c*.

Macrospore very large. Triradiate ridge occupying one-half of the upper surface. Area surrounding the three-armed star finely punctate; other portion of spore covered with numerous conical spines. This is easily distinguished from the last by its numerous stout spines and larger size.

Size.—2·3 mm. to 1·70 mm.
Horizon.—Millstone Grit.
Localities.—23, 24.

TRILETES VII. Pl. III., Figs. 7*a*, 7*b*, and 7*c*.

Macrospore similar in general character to *Triletes* VI., but smaller. The small apiculi on the area of the triradiate ridge are prominent; the mamillate spines are about the same size as those of the last form.

Size.—1·70 mm.
Horizons.—Millstone Grit and Coal Measures.
Localities.—24, 26, 34, 35, 36.

TRILETES VIII. Pl. III., Fig. 8.

This is closely allied to *Triletes* VII., but the spines are larger.

Size.—1·80 mm.
Horizon.—Coal Measures.
Locality.—35.

TRILETES IX. Pl. III., Figs. 9*a*, 9*b*, 9*c*, 9*d*, 9*e*, 9*f*.

Triradiate ridge extending over half of the upper surface; surrounding area ornamented with numerous small apiculi. Other portions of spore covered with numerous short, thick spines. Fig. 9*c* shows two of the spines in their natural condition, and three that have been flattened by pressure. Some specimens of this form have been found united in groups of four.

Size.—1·75 mm. to 1·6 mm.
Horizons.—Millstone Grit and Coal Measures.
Localities.—23, 25, 26, 27, 29, 33, 34, 35.

TRILETES X. Pl. IV., Figs. 10*a*, 10*b*.

Triradiate ridge occupying about one-half of the upper surface. Apiculi on triradiate area small; on other portions of spine distant and small on typical forms, but some varieties with larger spines occur in the Broomieknowe gathering, which it is difficult to separate from the type. It is quite possible, however, that two forms are included here; but awaiting further evidence, they are placed together.

Size.—1·82 mm.
Horizon.—Coal Measures.
Localities.—30, 31, 32, 33, 34, 35.

TRILETES XI. Pl. IV., Figs. 11*a*, 11*b*.

Triradiate ridge occupying about one-half of the upper surface, surrounded by an area bearing very small apiculi. Other parts of surface of macrospore bear very stout, somewhat distant and irregularly-disposed conical spines. The spines are more distant and stronger than on *Triletes* VIII. In some cases they bear comparatively few distant and irregularly-

TRILETES XIII. Pl. IV., Figs. 13*a*, 13*b*.

Macrospore small. Triradiate ridge very prominent, and occupying fully one-half of the upper surface. Surrounding area of triradiate ridge smooth, or very obscurely apiculate. Other portions of spore bear distant scattered stout short spines. Only a few specimens of this form have been met with.

Size.—1·3 mm.

Horizon.—Carboniferous Limestone Series.

Locality.—11.

Division III.—ZONALES.

In this division are placed those *Triletæ* on which the supposed parasitic *Stelideæ* occur. We have already expressed the opinion that the *Stelideæ* (including *Trichostelium* and *Stichostelium*) are integral parts of the spore on which they occur. That this is the true explanation of the equatorial zones will be best seen from a comparison of the fossils with some recent Lycopod macrospores. At Fig. 22*a* is given an enlarged drawing of the upper view of a macrospore of *Selaginella caulescens*. This spore is usually surrounded by a solid and gently undulating equatorial zone, the triradiate ridge extending from the centre of the spore to the border of the zone, where it becomes slightly pointed, imparting to the complete spore an obscurely triangular outline. Occasionally a few spines are scattered on the surface of the spore. This may be regarded as the normal form of the macrospore of *Selaginella caulescens*.

In this case it is quite impossible to do other than regard the equatorial zone as an integral part of the spore. But along with these solid-zoned macrospores a few others occur having slits in the zone, as shown at Fig. 22*b*. This slitting is sometimes carried further, when the zone in its inner part becomes divided into a number of pedicel-like branches supporting the peripheral portion, which may be solid or bear one or two small perforations.

If *Triletes* XVI., with its *Stichostelian-Stelideæ* (Pl. V., Fig. 16), is compared with the macrospores of *Selaginella caulescens*, the one is seen to be an exact counterpart of the

other in all particulars. Fig. 16*a* gives a corresponding view to that of the spore of *S. caulescens*, Pl. VI., Fig. 22*a*, where the zone is entire and solid. Fig. 16*c* corresponds to the enlarged portion of the zone of *S. caulescens*, Fig. 22*b*. The remarks made on the structure of *Triletes* XVI. apply equally to *Triletes* XVII. On *Triletes* XV., of which we have only seen a few examples, the zone is more divided than in *Triletes* XVI. or XVII., but the peripheral portion of the zone is usually united into a more or less solid margin (Pl. IV., Fig. 15*d*). On *Triletes* XIV. the zone is converted into a fringe formed of much flattened simple or one or more times divided hairs, placed closely together, in several series. In all these cases, except *Triletes* XIV., the zone is referable to Dr Reinsch's sub-tribe *Stichostelium*, but in *Triletes* XIV. it is probably referable to his sub-tribe *Trichostelium*.

From these considerations we have been led to unite Reinsch's *Stelideæ* with the various *Triletes* on which they occur.

TRILETES XIV. Pl. IV., Figs. 14*a*, 14*b*, 14*c*, 14*d*, 14*e*, 14*f*.

Disc of macrospore smooth, or very slightly granulated; spore wall thick. Triradiate ridge very prominent, considerably elevated, and occupying all the visible upper surface

beautiful bright amber colour when examined by transmitted light.

Size.—Including zone, 1·57 mm. to 1·45 mm. Diameter of disc, 1 mm. to 1·2 mm.

Horizons.—Millstone Grit and Coal Measures.

Localities.—24, 26, 35, 36.

TRILETES XV. Pl. IV., Figs. 15*a*, 15*b*, 15*c*, 15*d*, 15*e*, 15*f*.

Triradiate ridge prominent, and extending over about four-fifths of the upper surface of the spore. Other portions of the disc indistinctly granulate (Fig. 15*c*). Zone of irregular width, composed of flattened filaments, simple, clavate, or ramified and more or less united at their expanded apices.

The structure of the zonal appendages is shown at Figs. 15*d*, 15*e*, 15*f*. Fig. 15*d* illustrates the fusion of the filaments at their flattened and extended apices.

The zone forms a circle immediately outside of the extremities of the arms of the triradiate ridge, and slightly within the periphery of the (flattened) spore.

Diameter of disc, 1·36 mm. Width of zone very variable, attaining 0·51 mm.

Horizon.—Millstone Grit.

Localities.—23, 24.

TRILETES XVI. Pl. V., Figs. 16*a*, 16*b*, 16*c*; Pl. IV., Figs. 16*d*, 16*e*.

Form of macrospore, sub-triangular. Triradiate ridge extending to the base of the zonal appendages. Zone wide, solid or more or less irregularly perforated. The lower surface of the spore, especially towards its periphery, provided with short, stiff, adpressed, outwardly directed hairs.

Fig. 16*c* shows the structure of the zone. In many of the specimens the openings are closed by a delicate membrane. When viewed by transmitted light the appendages of the macrospores of this division (III.) are of an amber colour.

Specimens united in groups of four, which we believe to be referable to this form, have been found associated with the type.

Size, including zone, 1·94 mm.; diameter of disc, 1·1 mm.

Horizons.—Calciferous Sandstone Series and Carboniferous Limestone Series.

Localities.—7, 11 (?), 13, 17.

TRILETES XVII. Pl. V., Figs. 17*a*, 17*b*.

This form is closely related to the last, but the lower surface is covered with a dense coating of stout bristle-like hairs. The zone is occasionally solid, but sometimes divided into a number of flat filaments with expanded heads, which unite more or less among themselves. We were at first inclined to regard this form as a variety of the last, and although the differences between the two are difficult to express in words, we believe them to be of such a nature as to prohibit their being placed together. Specimens of this form in groups of four also occur.

Fig. 17*b* shows a portion of the zone, but the zone in this form of its parts, even on the same specimen (like the zone of the other specimens just described), varies much.

Size, including zone, 2 mm.; diameter of disc, 1·25 mm.

Horizon.—Coal Measures.

Localities.—29, 32.

TRILETES XVIII. Pl. V., Figs. 18*a*, 18*b*, 18*c*.

eventually splits into three subtriangular segments (Figs. 19, and 20 *a*, *b*, *c*, *e*). Outer surface smooth or bearing bristle-like hairs.

LAGENICULA I. Pl. VI., Figs. 20*a-s*.

Macrospore flask-shaped; outer surface provided with bristle-like hairs of various forms. Some of the chief forms of the hairs are shown at Figs. 20*f-s*. The hairs vary in outline, not only on different individuals, but on the same individual. The most common form of this macrospore is given at Figs. 20*a*, *b*, *c*, *d*. At Fig. 20*e* is shown another form which occurs in great quantities at Locality 1. This does not differ from the type except in size, but it may be conveniently distinguished as *var. major*.

In the neighbourhood of the trilabiate expansion the spines are smaller and less numerous, and on the lips they appear to be entirely absent. Figs. 20*n* and *f* are hairs from *var. major*; at Fig. 20*f* the bristle has a knob-like extremity; Figs. 20*g*, *h*, *i* may be such hairs with the extremities fractured; Figs. 20*l* and *k* give two other forms of knob-like hairs; and the remaining figures afford additional illustration of their diverse form. These epidermal appendages would also be most probably included by Reinsch in his *Stelideæ*. This form of macrospore is very plentiful in the Lower Carboniferous Limestone Series.

Size of type.—Trans. diam., 1·27 mm. to 1·1 mm.

Size of var. major.—Trans. diam., 2 mm. to 1·50 mm. Hirsute appendages vary much in length.

Horizons.—Calciferous Sandstone Series and Carboniferous Limestone Series.

Localities.—1, 2, 3, 4, 5, 6, 7, 8, 9, 11, 12, 14, 15, 16, 18, 19, 20, 21, 22, 37.

LAGENICULA II. Pl. V., Fig. 19.

Macrospore small and smooth.

Size.—Trans. diam., 0·90 mm.

Horizons.—Calciferous Sandstone Series; Carboniferous Limestone Series; and Coal Measures.

Localities.—8, 19, 28.

Explanation of Plates.

PLATE III.

Carboniferous Lycopod Macrospores.

Fig.	1*a*.	Triletes	I.	Upper Surface	×15	Locality	35
,,	1*b*.	,,	I.	Lower ,,	×15	,,	35
,,	2*a*.	,,	II.	Upper ,,	×15	,,	34
,,	2*b*.	,,	II. *var.* A	,, ,,	×15	,,	11
,,	2*c*.	,,	II. *var.* B	,, ,,	×15	,,	34
,,	3.	,,	III.	,, ,,	×15	,,	10
,,	4*a*.	,,	IV.	,, ,,	×15	,,	7
,,	4*b*.	,,	IV.	Lower ,,	×15	,,	7
,,	5*a*.	,,	V.	Upper ,,	×15	,,	23
,,	5*b*.	,,	V.	Lower ,,	×15	,,	23
,,	6*a*.	,,	VI.	Upper ,,	×15	,,	24
,,	6*b*.	,,	VI.	Lower ,,	×15	,,	24
,,	6*c*.	,,	VI.	Spines	×90		
,,	7*a*.	,,	VII.	Upper Surface	×15	,,	35
,,	7*b*.	,,	VII.	Lower ,,	×15	,,	35
,,	7*c*.	,,	VII.	Spines	×90		
,,	8.	,,	VIII.	Lower Surface	×15	,,	35
,,	9*a*.	,,	IX.	Upper ,,	×15	,,	26
,,	9*b*.	,,	IX.	Lower ,,	×15	,,	26
,,	9*c*.	,,	IX.	Spines	×90		
,,	9*d*	,,	IX.	Upper Surface	×15	,,	25
,,	9*e*.	,,	IX.	Lower ,,	×15	,,	23
,,	9*f*.	,,	IX.	Spines	×90		

Fig. 15*a*.	Triletes	XV.	Upper Surface	×15	Locality 23
,, 15*b*.	,,	XV.	Lower ,, Split Specimen	×15	,, 23
,, 15*c*.	,,	XV.	Portion of Lower Surface highly magnified to show granulation.		
,, 15*d*, *e*, *f*.	,,	XV.	Zonal Appendages	×280	
,, 16*d*.	,,	XVI.	Grouped Spores	×15	Locality 17
,, 16*e*.	,,	XVI.	,, ,,	×15	,, 17

PLATE V.

Carboniferous Lycopod Macrospores.

Fig. 16*a*.	Triletes	XVI.	Upper Surface	×15	Locality 17
,, 16*b*.	,,	XVI.	Lower ,,	×15	,, 17
,, 16*c*.	,,	XVI.	Zonal Appendages	×200	
,, 17*a*.	,,	XVII.	Lower Surface	×15	,, 29
,, 17*b*.	,,	XVII.	Zonal Appendages	×200	
,, 18*a*.	,,	XVIII.	Upper Surface	×15	,, 35
,, 18*b*.	,,	XVIII.	Lower ,,	×15	,, 35
,, 18*c*.	,,	XVIII.	Zonal Appendage (seen as an opaque object).		
,, 19.	Lagenicula	II.	. . . .	×15	Locality 28

PLATE VI.

Carboniferous Lycopod Macrospores.

Fig. 20*a*.	Lagenicula	I.	. . . .	×15	Locality 15
,, 20*b*.	,,	I.	. . . .	×15	,, 2
,, 20*c*.	,,	I.	. . . .	×15	,, 6
,, 20*d*.	,,	I.	. . . .	×15	,, 14
,, 20*e*.	,,	I. *var. major*	. .	×15	,, 1
,, 20*f-s*.	,,	I. Hirsute Appendages		×200	

Recent Lycopod Macrospores.

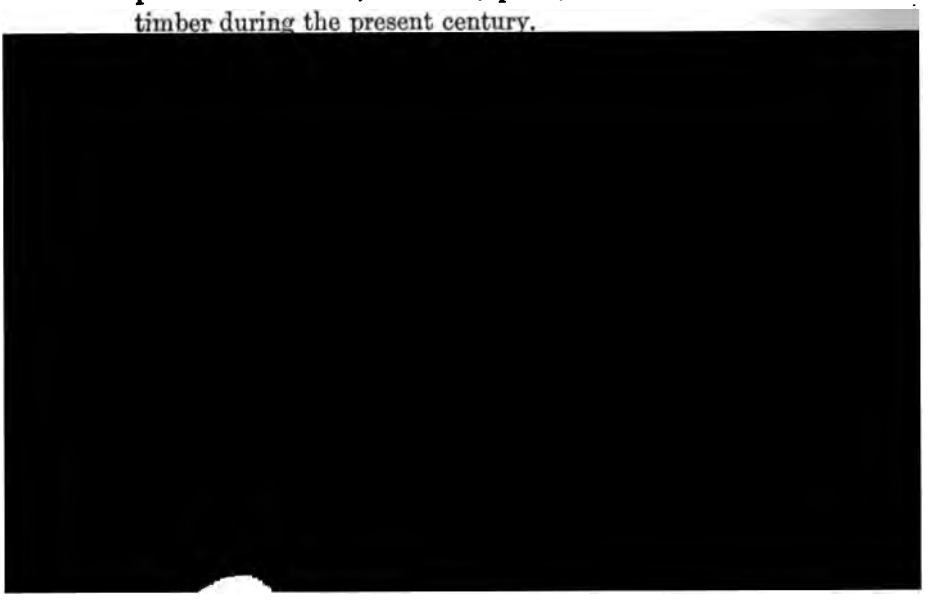
,, 21.	*Isoëtis lacustris*, Linn.,	. . . .	×60
,, 22*a*.	*Selaginella caulescens*, Spring,	. .	×60
,, 22*b*.	,, ,, Portion of zone of another individual, highly magnified to show the perforations.		
,, 23.	*Selaginella Martensii*, Spring,	. .	×60
,, 24.	,, *hæmatodes*, Spring,	. .	×60
,, 25.	*Isoëtis echinospora*, Durien,	. . .	×60

Note.—My thanks are due to Mr R. Lindsay, Royal Botanic Garden, Edinburgh, and to Mr G. Nicholson, Royal Botanic Gardens, Kew, for kindly providing me with fruiting specimens of Recent Lycopods for the purpose of comparing their macrospores with these fossils.

VIII. *The Birds of Skye, with special reference to the Parish of Duirinish.* Part I., 1886. By the Rev. H. A. MACPHERSON, M.A., Member British Ornithologists' Union.

(Read February 1886.)

The field notes, which constitute the basis of the present report, have been written during various visits paid to Skye since April 1882, and relate chiefly to that western portion of the Island which consists of the promontories of Duirinish and Waternish, including an area of about a hundred square miles. This elevated region possesses many and varied features, long undulating spurs of bleak moorland alternating with sheltered glens and considerable stretches of arable land, whilst a few small fresh water lochs are interspersed. The precipitous coast-line, worn by the waters of the Minch, includes the magnificent headlands of Waterstein and Galtrigill; but in the neighbourhood of Dunvegan, the hills sink by graduated terraces to the sea-level. Natural wood is scarce in this wild district, alder, hazel, and willow being only local in distribution; but a large extent of ground at Dunvegan, Lynedale, Waternish, and Greshornish has been planted with larch, Scots fir, plane, and other varieties of timber during the present century.



list; and it is hoped that such blanks as exist may be filled up by future observations. Whatever the utility of the present report may be, very cordial thanks are due to the gentlemen who have contributed various items of information, especially to Captain Macdonald of Waternish, Mr Dumville Lees, and Captain Cameron. My friend Mr Harvie-Brown, whose acquaintance with Skye extends over twenty years, has kindly added the notes which bear his initials.

About 153 species are recorded as occurring in Skye; *Sylvia nisoria*, *Sitta cæsia*, and *Puffinus major* being virtually new to the Hebrides.

Turdus viscivorus.—Resident, but scarce in Northern Skye. Mr Seebohm states that it was formerly much more plentiful, its numbers having been decimated by the severe winter of 1879-80.

Turdus musicus.—A prolific resident, nesting on the shrubless Ascrib Isles, and in other wild situations, but rather later than in Southern Britain. I have seen the young fly in Skye on May 8th, but this occurred in a walled garden. Mr O. V. Aplin, remarking on specimens I sent him, observes:—"A bird in nest dress from Skye is everywhere of a slightly deeper tint than Oxfordshire nestlings. In an adult from the same locality (April), the brown of the upper parts has less yellow in it, and is therefore colder and darker than in Oxon birds, and the face and breast show much less of the yellowish buff ground colour, being nearly white; the spots also appear to be darker."

Turdus iliacus.—Winter visitant, but not in large numbers.

Turdus pilaris.—Winter visitant; large droves frequently occurring on the vernal migration.

Turdus merula.—Resident in wooded districts, but more numerous as a *winter* visitant. Many males of the year arrive in November, haunting the braes above the sea and other sheltered situations; departing in March.

Turdus torquatus.—Summer visitant, but not numerous. Captain Macdonald shot a pair at Waternish one spring. Mr Dumville Lees has also met with it.[1]

[1] In 1886 a pair of Ring Ouzels nested at Waternish; another pair reared a brood on Waterstein, carrying worms to the young in my presence.

Explanation of Plates.

PLATE III.

Carboniferous Lycopod Macrospores.

Fig.							
,,	1*a*.	Triletes	I.	Upper Surface	×15	Locality	35
,,	1*b*.	,,	I.	Lower ,,	×15	,,	35
,,	2*a*.	,,	II.	Upper ,,	×15	,,	34
,,	2*b*.	,,	II. *var.* A	,, ,,	×15	,,	11
,,	2*c*.	,,	II. *var.* B	,, ,,	×15	,,	34
,,	3.	,,	III.	,, ,,	×15	,,	10
,,	4*a*.	,,	IV.	,, ,,	×15	,,	7
,,	4*b*.	,,	IV.	Lower ,,	×15	,,	7
,,	5*a*.	,,	V.	Upper ,,	×15	,,	23
,,	5*b*.	,,	V.	Lower ,,	×15	,,	23
,,	6*a*.	,,	VI.	Upper ,,	×15	,,	24
,,	6*b*.	,,	VI.	Lower ,,	×15	,,	24
,,	6*c*.	,,	VI.	Spines	×90		
,,	7*a*.	,,	VII.	Upper Surface	×15	,,	35
,,	7*b*.	,,	VII.	Lower ,,	×15	,,	35
,,	7*c*.	,,	VII.	Spines	×90		
,,	8.	,,	VIII.	Lower Surface	×15	,,	35
,,	9*a*.	,,	IX.	Upper ,,	×15	,,	26
,,	9*b*.	,,	IX.	Lower ,,	×15	,,	26
,,	9*c*.	,,	IX.	Spines	×90		
,,	9*d*.	,,	IX.	Upper Surface	×15	,,	25
,,	9*e*.	,,	IX.	Lower ,,	×15	,,	23
,,	9*f*.	,,	IX.	Spines	×90		

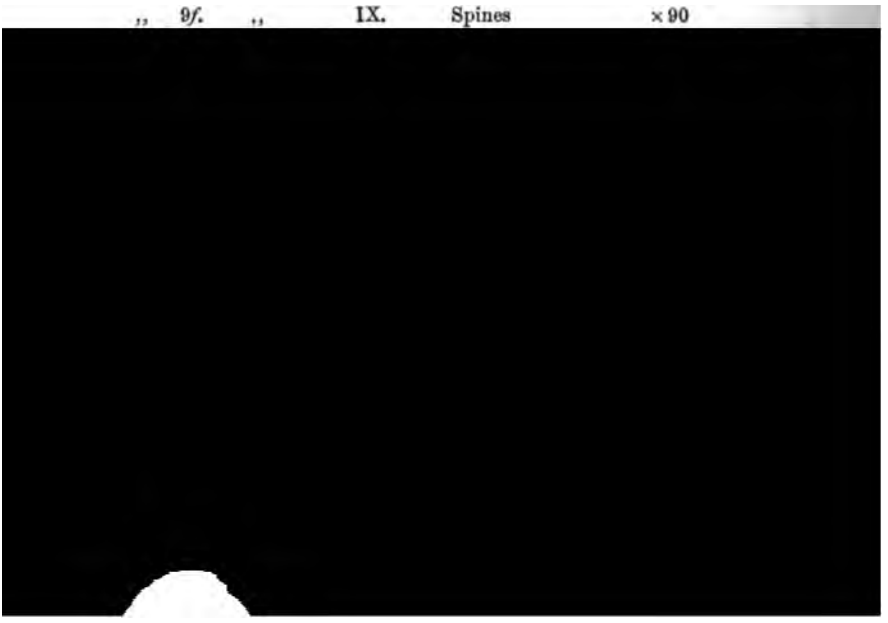


Fig. 15*a*.	Triletes	XV.	Upper Surface	×15	Locality 23
,, 15*b*.	,,	XV.	Lower ,, Split Specimen	×15	,, 23
,, 15*c*.	,,	XV.	Portion of Lower Surface highly magnified to show granulation.		
,, 15*d*, *e*, *f*.	,,	XV.	Zonal Appendages	×280	
,, 16*d*.	,,	XVI.	Grouped Spores	×15	Locality 17
,, 16*e*.	,,	XVI.	,, ,,	×15	,, 17

PLATE V.

Carboniferous Lycopod Macrospores.

Fig. 16*a*.	Triletes	XVI.	Upper Surface	×15	Locality 17
,, 16*b*.	,,	XVI.	Lower ,,	×15	,, 17
,, 16*c*.	,,	XVI.	Zonal Appendages	×200	
,, 17*a*.	,,	XVII.	Lower Surface	×15	,, 29
,, 17*b*.	,,	XVII.	Zonal Appendages	×200	
,, 18*a*.	,,	XVIII.	Upper Surface	×15	,, 35
,, 18*b*.	,,	XVIII.	Lower ,,	×15	,, 35
,, 18*c*.	,,	XVIII.	Zonal Appendage (seen as an opaque object).		
,, 19.	Lagenicula	II.	. . . .	×15	Locality 28

PLATE VI.

Carboniferous Lycopod Macrospores.

Fig. 20*a*.	Lagenicula	I.	. . . .	×15	Locality 15
,, 20*b*.	,,	I.	. . . .	×15	,, 2
,, 20*c*.	,,	I.	. . . .	×15	,, 6
,, 20*d*.	,,	I.	. . . .	×15	,, 14
,, 20*e*.	,,	I. *var. major*	. .	×15	,, 1
,, 20*f-s*.	,,	I. Hirsute Appendages		×200	

Recent Lycopod Macrospores.

,, 21.	*Isoëtis lacustris*, Linn., ...	×60	
,, 22*a*.	*Selaginella caulescens*, Spring, . .	×60	
,, 22*b*.	,, ,, Portion of zone of another individual, highly magnified to show the perforations.		
,, 23.	*Selaginella Martensii*, Spring, . .	×60	
,, 24.	,, *hæmatodes*, Spring, . .	×60	
,, 25.	*Isoëtis echinospora*, Durien, . . .	×60	

Note.—My thanks are due to Mr R. Lindsay, Royal Botanic Garden, Edinburgh, and to Mr G. Nicholson, Royal Botanic Gardens, Kew, for kindly providing me with fruiting specimens of Recent Lycopods for the purpose of comparing their macrospores with these fossils.

negatived by Captain Macdonald's description of the *lower* parts.[1]

Certhia familiaris.—Resident at Skeabost, where I have repeatedly seen the Tree creeper, and probably of general distribution. Mr Dumville Lees has also met with it.

Troglodytes parvulus.—Resident, and pretty numerous. The *bars* upon the flanks and back are *darker* and more pronounced in Skye wrens than in wrens from southern Britain. The bill and feet of the Skye birds appear to be a trifle stronger than in English specimens, but the difference is very slight.

Motacilla lugubris.—Summer visitant, nesting sporadically in cultivated districts.

Motacilla melanope.—Summer visitant, but not numerous. A brood were reared near Hamar in 1885. Mr T. Robertson has observed the Grey Wagtail at Greshornish in winter.

Anthus pratensis.—Summer visitant: the commonest small bird on the hillside in the nesting season.

Anthus obscurus.—Resident, nesting on the Skinidin and Colbost islands, and also at Miloveig and Hamar. In the winter of 1883-84 a charming Rock Pipit constantly haunted our precincts at Hamar, flitting about the outhouses with the fearlessness of a Robin, and even venturing on to the

south of Skye. Mr Macdonald, Tormore, informs me that a pair of Goldfinches nested in his garden in Sleat a few years since.

Ligurinus chloris.—Winter visitant; and the flocks, which gather round farm buildings, linger into April, but I have no evidence at present of its nesting with us.

Passer domesticus.—A common resident, breeding at Greshornish, Dunvegan, Waternish, and no doubt generally distributed; to Hamar it was a regular *winter* visitant, but remained to breed with us numerously in 1886.

Fringilla cœlebs.—A numerous resident, though most abundant in winter, when large flocks of both sexes appear. When trees are scarce the Chaffinch builds near the ground, *e.g.* (last July), a nest built into a low bush, and almost on the ground, at the edge of a low cliff above Skinidin. A male at Hamar constantly sang from a low *grassy knoll*, though his nest (like those of two other pairs) was built in the fir plantation behind the house. He never sang on a gate or dyke, but always on *terra firma*.

Linota cannabina.—Resident, but probably scarce; at all events I have not found any reference to it in my notes, though Mr Lees reports its presence in the Broadford district.

Linota rufescens.—Summer visitant, I imagine; at least I have only seen it in summer. In July 1884 I watched a pair feeding their young at Greshornish. In July 1886 I saw a family party near Dunvegan.

Linota flavirostris.—Resident, gathering into flocks of from a dozen to more than a hundred birds in autumn, and flocking late into spring. In 1883 I saw a *flock* of between twenty and thirty feeding on some rough ground on May 20th.

Pyrrhula europœa.—Resident (?). The only example I have seen was a fine male at Greshornish, April 1885, but it is said that the Bullfinch breeds generally in Sleat. [The Bullfinch occurs through the wooded parts of the south-east of Skye or Sleat, though Seebohm appears to doubt its occurrence at all in the Hebrides.—J. A. H. B.]

Emberiza miliaria.—A numerous resident, droning its

NOTE.—*Passer montanus.*—In July 1886 I narrowly examined this species at Uig, close to the post-office. It is doubtless resident.

sonorous song the livelong day in the Hamar firs, as well as on all the dykes and in the cornfields. When the gloaming comes it is pretty to see the Buntings which have been scattered over the fields during the day gathering into flocks and wheeling to and fro in Starling fashion prior to repairing to roost in the plantation. I have twice observed individuals in Skye which were slightly pied.

Emberiza citrinella.—A plentiful resident, which often omits the latter part of its song in Skye.

Emberiza schæniclus.—Resident, and not uncommon, in marshy situations.

Plectrophanes nivalis.—Winter visitant; observed by Mr Lees and occasionally by Captain Macdonald. An interesting instance of the well-known trait of this Bunting in perching came under my notice, December 1st, 1883. I was walking along the edge of the fir plantation at Hamar when the Snowflake's familiar twitter caught my ear, and I spied a party of five perching on the upper branches of a fir. On my close approach the birds flew from tree to tree until they reached the end of the plantation, when they rose and departed in the direction of Macleod's Tables.

Alauda arvensis.—Summer visitant, nesting chiefly on the verge of arable land. In May, begins to sing at 1.30 A.M.

Sturnus vulgaris.—Resident, nesting in crevices of the

both on inland ranges of cliffs, and on the east coast of Skye.

Pica rustica.—Casual visitant. A single Magpie was observed at Waternish in May 1882 by Captain Macdonald, who had not seen one for many years previous.

Corvus monedula.—Resident, but scarce. A pair nested at Miloveig in 1882. There is a colony at Dunvegan.

Corvus corone.—Resident, but very scarce. Charles Shaw, who trapped great numbers of Carrion Crows on a shooting in the South of Scotland, informs me that he has met with undoubted Carrions in Duirinish—the last in the autumn of 1885. Mr Dixon also met with it.

Corvus cornix.—Resident; and though an expert oologist, the Hoodie feeds largely on fish offal and flotsam or jetsam. All those I have examined in Skye have been pure bred. [In some districts, however, it has become almost extinct or very scarce—as, for instance, around Bracadale Manse, where the keepers have been slaughtering them wholesale for years.—J. A. H. B.]

Corvus frugilegus.—Resident, and increasing. Two fine Rookeries exist near Dunvegan, a third at Skeabost, a fourth at Greshornish; they would nest, if permitted, at Lynedale and Waternish. The Skeabost and Greshornish colonies are not of twenty years' standing, but the Rook must be an *old* resident in Skye, for more than forty years ago the Rev. J. Mackinnon, minister of Strath, wrote:—"A rook with white wings has been observed in the parish." There is also a Rookery at Gesto, in the Parish of Bracadale (*auct.* Rev. John M'Lean); another at Carbost; another at Herpur.

Corvus corax.—Resident; nesting when permitted at Greshornish, Waternish, Galtrigill, Miloveig, Ramasaig, Lowergill, generally rearing four young on the face of an overhanging precipice.[1] On January 4th last, I enjoyed a good view of a Raven hotly chevying a Hooded Crow across Dunvegan Loch, whence he returned with many a triumphant

[1] In Ulinish Macdonald killed twenty-five Ravens between November 1885 and July 1886. Similar numbers are killed in some years on the Portree shooting. Three pairs nested in Glendale in 1886, one brood flying at the end of May, the others later.

croak to join his sympathetic mate in casting to and fro in search of some carrion on the ridge of Fasach.

Cypselus apus.—Casual visitant, occasionally observed by Captain Macdonald, by myself, and Mr J. Mackenzie.

Caprimulgus europæus.—Summer visitant to the south of Skye; apparently absent from Duirinish.

Alcedo ispida.—Casual visitant, according to Mr R. Gray; but it has not occurred of late years.

Cuculus canorus.—Summer visitant; most obstreperous in the gloaming, when the challenge of the males to the "whittling" female awakes the remonstrances of the sleepy thrushes. In 1882 I observed a cuckoo regularly tired out by its long passage; it spent most of two days (May 3d and 4th) resting on a low stake, and seemed to be recruiting.

Strix flammea.—Resident; no doubt nesting among the rocks at Miloveig and elsewhere, as it does in Eigg. Mr T. Robertson saw one at Skeabost in the spring of 1883, and three were obtained at Waternish in the spring of 1884. Captain Macdonald has observed it on other occasions, and Macleay has received examples from Skye.

Asio otus.—Resident; breeding in the Dunvegan woods, whence it strays to Waternish occasionally. Macleay has received specimens from other parts of Skye. Not uncommon about Bracadale. Breeds near the Ulinish shooting lodge.

informs me that in 1873 he knew of five nests of the Harrier, and killed twenty-five birds, old and young. He did not meet with the species again until 1883, when he trapped a hen bird at her nest. I observed a Harrier the same year on Waterstein. A male in adult dress is preserved at Greshornish.

Buteo vulgaris.—Resident in the centre of Skye, but only a casual visitant now to Duirinish. Captain Cameron tells me that two pairs used to breed at Tallisker. I had a fine bird, in its second year, from Eigg in 1885.

Archibuteo vulgaris.—Casual visitant. Captain Macdonald informs me that two or three have been obtained at Armadale.

Aquila chrysaetos.—A casual visitant to Duirinish, where a few years since a fine bird was captured by a sheep dog whilst fighting on the ground with another Eagle. Maclean, the lad who caught it, and who is now in the Falkland Isles, described its capture to me. He sent it to Mr H. Parsons of Oxford, from whom I learn that it is still flourishing in captivity. Sheriff Spiers has a Skye specimen, and Mr Spence Bower occasionally observes the Golden Eagle in Strath. Formerly a pair nested on Loch Coruisk as Captain Macleod and Captain Cameron inform me, and the latter gentleman sent full details to Mr R. Gray, adding that of 65 Eagles killed in Skye only three were Golden Eagles. Harvie-Brown in June 1883 picked up a wing feather of a Golden Eagle on the strand of Loch Coruisk, which had apparently quite recently been dropped. Mr Dixon states (Seebohm, "B. B.," vol. i., p. 101), that in 1881 he visited a nest of this species on the west coast of Skye, and twenty-four miles from Portree, the breeding female having been captured the previous day.

Haliaetus albicilla.—Resident; a pair or two still breeding in the south and west of Skye. Captain Macleod once descended to an eyrie on the south coast of Skye. Until the last few years a pair generally nested at Dunvegan Head, and two Eaglets which Captain Macdonald took from this nest became his familiar companions, descending from a great elevation to join him on his walks, answering his whistle, and retrieving the game he shot for their own larder.

In August 1879 a single nestling was shot out of the nest by Mr H. Parsons, jun. The nest, which I have visited, was placed on a pillar of rock, and easily approached by a long sheep track; but the shoulder of the pillar defied ascent, and as the nest could not be reached from above, the feathered nestling was shot. In 1881 the old birds bred about half a mile further north, but I do not think that they bred there for the last two seasons, and I doubt if they bred there in 1883. Formerly there was an eyrie of this Eagle on the Ascrib Isles; and the precipices of Miloveig and those of Waterstein always held a pair within the recollection of living men. At present they are decidedly scarce, and only very few eyries are inhabited.

Astur palumbarius.—Accidental visitant. Captain Macdonald shot a Goshawk in the month of March, he believes, in 1870. It was resting on a rock at the side of a loch. On dissection he found that it contained a number of lizards.

Accipiter nisus.—Resident at Dunvegan, but decidedly a scarce bird. Bred at Dunvegan in 1885.

Milvus ictinus.—Resident in the south of Skye, as I learn from Mr Lance Bower, but nearly extirpated. Mr Dixon states that he found a kite nailed up by a keeper in 1881 (Seebohm, "B. B.," i., p. 75).

Falco candicans.—Accidental visitant. A Greenland

Falco æsalon.—Resident, generally distributed, but not very plentiful, though I know of two localities where the Merlin breeds every year. From one of these, in a wild glen, overshadowed by one of Macleod's Tables, I took the young in feather on June 28th in 1884, but we always endeavour to spare the old ones, and I only know of one trapped on the property in the last four years. In 1885 we found the young strong winged on July 13, and examined their dissecting table, a huge slab of grey rock, festooned with moss and yellow lichen, the moss torn by the claws of the Merlins, and befouled by their rejecta and the feathers of their quarry—Meadow Pipits and Wheatears.[1]

Tinnunculus alaudarius.—Resident, nesting about Dunvegan Head. I have observed its presence in mid-winter. In May 1883 I took a Kestrel out of a trap on Waterstein, which Mr O. V. Aplin recorded as "a fairly old male, with bluish head and tail; this colour was very pale, and the red of the body was really more of a yellowish brown, and presented a most *washed out* appearance" (*Zool.*, 1884, p. 68).

Pandion haliaetus.—Casual visitant. An Osprey, shot on Loch Bracadale in May 1878, is preserved at Dunvegan Castle.

Phalacrocorax carbo.—Resident, nesting sparingly on our coasts. "On the south side Loch Portry," says Martin, "there is a large Cave, in which many Sea Cormorants do build: the Natives carry a bundle of Straw to the door of the Cave in the Night-time, and then setting it on fire, the Fowls fly with all speed to the Light, and so are caught in Baskets laid for that purpose."

Phalacrocorax graculus.—Resident, nesting about Lowergill and at the Ascribs. Immature Shags haunt our rocks all the year round. "A Cormorant," says Martin, "which has any white Feathers or Down, makes good Broth."

Sula bassana.—Summer visitant, stragglers appearing on Loch Dunvegan at the beginning of April, and knocking about the Minch the summer long. A bird of the year at

[1] In 1886 two pairs of Merlins nested with us; one nest contained a plucked Chaffinch. Another pair tried to breed in Ulinish, but were trapped.

the Zoological Gardens at present consumes eight whitings per diem.

Ardea cinerea.—Resident, a fine heronry existing in a wild glen about a mile north of Dunvegan. There are one or two more heronries in the south of Skye. No doubt, before trees were planted, the Herons bred among the rocks, as a pair or two still do on the west side of Eigg. Martin observes of this species—"I have seen sixty on the shore in a Flock together."

Botaurus stellaris.—Rare casual visitant, a single Bittern, in the possession of Captain Macdonald, and shot at Skeabost, being, no doubt, the identical specimen mentioned by Mr R. Gray as shot in Skye in May 1867—probably on information supplied by the late Dr Dewar, who was a mutual friend of Captain Macdonald and Mr R. Gray.

Anser cinereus.—Winter visitant, observed in the vicinity of Loch Waterstein every November. Possibly the Grey Lag still breeds in Skye, for I learn from Mrs H. Macdonald that she recollects a shepherd of her father's in Strath bringing home from the hill a sitting of Wild Goose eggs, which were duly hatched out. Captain Macdonald informs me that the Grey Lag Goose bred on the Ascribs until 1867, and would do so still if unmolested, even now visiting the old haunts in spring. Two fine birds, reared from Uist eggs by

Cygnus musicus.—Winter visitant, occasionally observed by Captain Macdonald. The Rev. R. Macgregor states:—"Until St Columba's Lake [in North Skye] was drained [1829], it was yearly frequented by large flocks of Swans, which appeared on October 25th, and remained five months" (New Stat. Acct., vol. xiv., p. 250).

Tadorna cornuta.—Mr R. Gray states that the Sheldrake is numerous in Skye, but it is certainly uncommon on the N.W. coast, though a pair or two often nest on Eilon Isay. Shaw saw a party of Sheldrakes at the mouth of the Skinidin river, Dec. 1885. (I have seen it repeatedly in Eigg, but not in Skye.) They are, however, common in N. Uist, across the Little Minch. One shot near Struan, winter 1885-86.

Anas boschas.—Resident, nesting about the lochs inland. I found a very pretty nest, one year, on the Colbost island. The number of residents does *not* seem to receive *any addition* in winter, and Baron Gudin, who is a great Duck-shooter, expressed surprise at the comparatively small quantity of Mallard on the Drynoch shootings.

Querquedula crecca.—Winter visitant, less plentiful of late years. The Teal nests on Eilon Isay and in Ulinish.

Mareca penelope.—Winter visitant, but in comparatively scanty numbers. My latest spring date for the presence of this species is April 19th. [Widgeon frequent Kinloch Harport during the season (*auct.* Rev. J. M'Lean).—J. A. H. B.]

Clangula glaucion.—Winter visitant, stragglers turning up occasionally. Captain Macdonald shot a young drake on a fresh-water loch in 1884, but considers it scarce in Skye, though numerous on the other side of the Minch. ("Young bird"—*i.e.*, bird of the year.)[1]

Harelda glacialis.—Winter visitant—Mr Gray says in large numbers. Captain Macdonald has a young female, which he shot out of a small party. Captain Cameron has seen it on Loch Bracadale.

Somateria mollissima.—Winter visitant of irregular occurrence. A small party wintered on Dunvegan Loch in 1885-86. Two pairs nested on the Ascribs in 1884, but

[1] A party of thirteen Goldeneyes haunted Loch Waterstein in the spring of 1886, departing at the end of April.

the Uig fishermen robbed the nests. [Thirty years ago the Eider was confined to the west coast of Uist. It has now made its way to the Sound of Harris, and all along the east or Minch side of the same island, and has been spreading and increasing steadily of late years, both on salt-water and fresh-water islands.—J. A. H. B.]

Mergus merganser.—Winter visitant, the stories of its nesting being unsatisfactory. Captain Macdonald has a fine adult Drake, shot by a keeper on Loch Bracadale some years ago.[1] Mr Dumville Lees has also met with it.

Mergus serrator.—Resident; and having afforded me many opportunities of close study, I venture to forego my rule of brevity, and to give lengthened details of its habits.

It is on *islands* in Dunvegan Loch, off Waternish, and on Loch Greshornish, that the Merganser chiefly nestles, though a pair generally tenant a cairn at Leinish, on the "*mainland*" of Skye, and another pair nested on the "mainland" at Greshornish in 1885. I have found the nest placed in a slight cavity surrounded by tall heather, and also placed in a rabbit-hole; but the usual situation is the interior of a cairn among the rocks, screened from view by large tufts of lady-fern. The centre of a patch of bracken is sometimes preferred.

The nest lining is scanty, and consists of a few pieces of dried bracken, straws, and some feathers the grey down

ment, the female sits very closely, and only quits the nest most reluctantly. The male is generally in the vicinity.

During winter, the Mergansers of the year are gregarious; but the old males are often solitary, and may frequently be observed diving alone in some favourite bay, or skimming rapidly over the water, exhibiting a large extent of white in the wing. But though, when alarmed, or desirous of shifting quarters, Mergansers generally rise low on the wing, soon dropping again; yet in early spring they are fond of "flighting" in the evening, nine or ten birds flying together at a respectable height. Breeding couples are paired by the middle of April, and it is entertaining to watch the movements of a rejected suitor, following bashfully in the rear of the fair one whose favour he has failed to secure; on such occasions the paired drake constantly contrives to interpose between the forlorn bachelor and his lady-love. Even in the breeding season the Merganser is a shy species; and though they often swim into the shelter of rocks, so that one can lie in wait for them, yet I have not yet seen a Merganser escape by *diving*. On Dunvegan Loch they always rise, if alarmed, upon the wing, though they generally drop into the sea again before they have flown very far. Neither have I seen them circle round a boat; they prefer to go off in a nearly straight line, calculating their distance. They are fond of feeding in the shallows at the mouths of burns. At the mouth of the Greshornish river an old male may often be seen feeding—not diving (the water is too shallow), but feeding stern uppermost. Only once have I happened to see the Merganser *ashore*, when not nesting; in this instance we surprised a pair one afternoon which were resting ashore on some tangle-covered rocks on the east side of Dunvegan Loch. A bird of the year has been living, to my knowledge, for three months in a coop in Leadenhall, and the poor captive seems to thrive amazingly well upon his straw litter.

The fact that the Merganser does not increase in numbers on Dunvegan Loch is probably due to the fact that the tenants often take the eggs when gathering whelks; but Captain Macdonald informs me that *Larus marinus* is a dire foe to the downy young.

A downy nestling, obtained on Dunvegan Loch at the beginning of August, measured 7½ inches. The upper parts were chocolate, fringed on the neck with reddish; wings dark brown, edged with buffish; a white spot on the flank, and another behind the thigh; lower parts buffy-white; bill reddish-brown; unguis and tip of lower mandible pink; *tarsi*, in front OLIVE, behind blackish; webs nearly black. In all the immature birds examined by me, the *tarsi* have been red or orange. It would appear that the change in the colour of these parts from olive and black to orange takes place during the first few weeks of life.

Columba palumbus.—Resident, but not numerous. I saw a pair at Uiginish last April, and five at Dunvegan last December. Captain Macleod and Captain Macdonald consider it rather scarce. Mr Dumville Lees has met with it.

Columba livia.—Resident, though perhaps decreasing, owing to cattle being fed more indoors in winter than formerly. The birds of our caves breed always *true* to colour. In 1882, I found nestlings *in nido* on June 1st, but saw fair fliers on June 17th. Those I have opened were crammed with oats.

Phasianus colchicus.—Resident and numerous at Lynedale, as also Waternish, the birds of the latter colony having been introduced from Raasay.

Baron Gudin secured black game on the Drynoch shootings in 1883, but seemed to think it scarce.

Rallus aquaticus.—Mr R. Gray states ("B. of W. of S.," p. 334), that he formerly received examples from Skye.

Crex pratensis.—Summer visitant, arriving before our late herbage is long enough to conceal its lythe form, and therefore affording us opportunities of watching its "craking," as it rapidly twists its neck from side to side. The pair which nest annually in the walled-garden at Hamar, generally lead their brood out to fresh pastures through an open door. One day the old female miscalculated, and triumphantly led her brood into the kitchen.

Gallinula chloropus.—Is included in the New Statistical Account as resident in the south of Skye. Mr Lees reports its presence in the Broadford district.

Fulica atra.—Resident (?). A pair appeared one year at Loch Waterstein, and perhaps bred there. A Coot was shot at Greshornish, December 1885, perhaps a straggler from N. Uist.

Charadrius pluvialis.—Resident, breeding numerously on our braes and broken ground. An old bird, which I shot in July 1884, had white primaries.

Ægiatalis hiaticula.—Resident, a few pairs nesting on a sandy shore near Ardmore (as they do in Eigg, where I have found several nests). Shaw shot two rather large birds out of a small flock, on Loch Dunvegan, January 1886.

Vanellus vulgaris.—Summer visitant, numbers breeding at Waternish, and a few at Skeabost, departing south in early autumn. I once saw a single Peewit on a rock at Loch Pooltiel, the last place I should have expected.

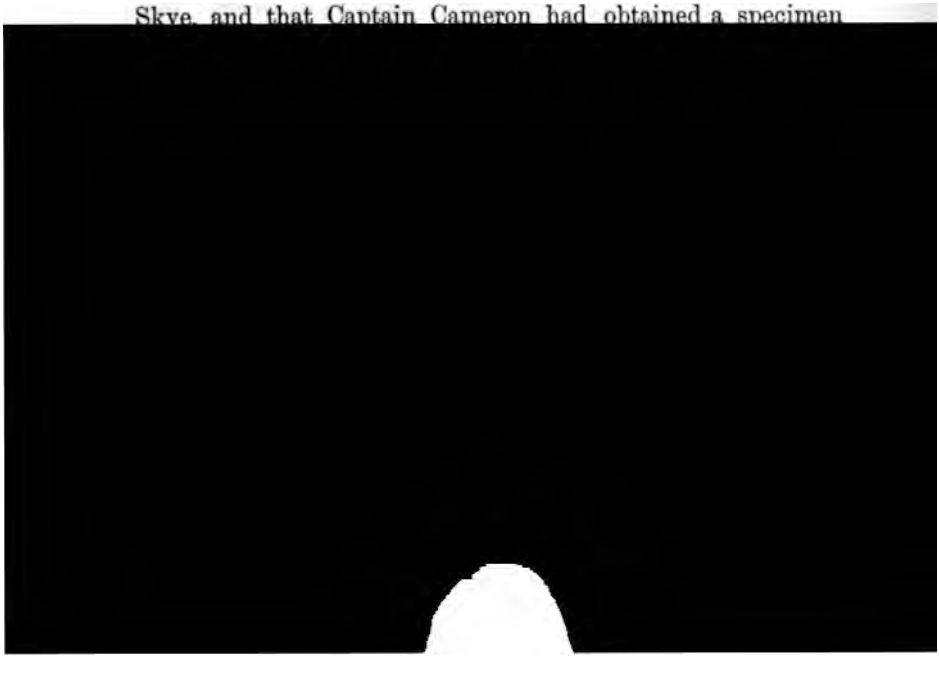
Strepsilas interpres.—Periodical visitant, chiefly observed by Captain Macdonald on the Ascribs during the vernal migration; noticed also by Messrs T. Robertson and Dumville Lees. [Harvie-Brown found a pair in full breeding plumage on the outermost Ascrib Island, but feels sure they had no eggs or young.[1] This was on the 19th June 1885.—J. A. H. B.]

[1] On 3d July 1886 I saw two pairs of Turnstones on Loch Bracadale in summer plumage, but certainly barren birds. They were feeding on the exposed tangles.

Hæmatopus ostralegus.—Resident, nesting on low islands, less frequently on precipitous stacks. I have only once found *four* eggs in a clutch in Skye, *i.e.*, in May 1883, on a Skinidin Island.

When visiting the Ascribs with Captain Macdonald, at the end of June 1884, we captured some Oyster Catchers, which were loth to run, insisting on attempting to conceal themselves by squatting in the rough herbage. We placed one of them in a luncheon basket. At first we fed it on limpets, and when these ran short, earthworms were tried. At first it declined to pick up, but hunger on the third day induced it to feed itself; at breakfast that day he bolted eight worms (10 A.M.); at 2 P.M., eleven; at 7.30 P.M., thirteen; sometimes he seized two at once, and the more the worm objected, the keener grew *ostralegus* to try his flavour. After supper that evening, he plunged incontinently into a box of Puffin eggs, thence dropping on to the floor. There arrived, the grate suggested itself as a cave of Adullam, but he so often came to grief over the fire-irons, that he began to dislike that part of the room. "As I write," says my diary, "I hear his low reproachful whistle."

Phalaropus hyperboreus.—Casual visitant. Mr R. Gray states that he obtained a specimen in breeding dress from Skye, and that Captain Cameron had obtained a specimen



Gallinago cœlestis.—Resident, nesting on Waterstein and in other suitable situations. In 1885 I observed the Snipe "bleating" on July 13; presumably the birds were nesting for the second time.

Gallinago gallinula.—Winter visitant, but Captain Macdonald considers that the species has become scarce latterly. A Jack Snipe was shot near Hamar in August 1884.

Tringa alpina.—Casual visitant; at least I have only once seen the Dunlin in Skye. Mr Dumville Lees and Captain Macdonald have both met with it.

Tringa striata.—Periodical visitant, observed by Captain Macdonald every year on the Ascribs in May, but not later. In 1883 I observed a pair on an island in Dunvegan Loch on May 16th, evidently on passage. Mr T. Robertson shot one in winter.

Tringa canutus.—Casual visitant. To my surprise I found a party of about twenty Knots in grey winter dress haunting the shores of Dunvegan Loch, wherever they could find a little mud, *e.g.*, at the mouth of the Skinidin burn, in January 1886.

Totanus hypoleucos.—Summer visitant, a few pairs nesting on all the lochs and burn sides. In 1883 a clutch of eggs was brought to me from Colbost in May. In 1884 we observed *newly* fledged birds in the middle of June.

Totanus calidris.—Winter visitant to Duirinish; I have observed odd birds *in summer* in Skye. Captain Macdonald finds it very troublesome when he is stalking seals. Mr Dumville Lees has kindly indicated a breeding station near Broadford.

Totanus canescens.—Summer visitant, nesting, as recorded by Mr R. Gray, near Sligachan, where eggs have been taken by Angus Nicholson and Mr Ross, and where Mr Seebohm, jun., obtained downy young (Seebohm, "B. B.," vol. iii.). Mr Dumville Lees shot a Greenshank near Broadford, October 1885. It is on the whole a rare bird in Skye, and I hope ornithologists will not come to Skye in search of it.

Numenius phæopus.—Periodical visitant, numerous on sea lochs in May. Mr Dumville Lees writes:—"In October last (1885) I saw a Whimbrel off the Irishman's point near Broadford."

Numenius arquata.—A numerous resident, nesting near Portree and Skeabost, and I suspect also at Leinish.

Sterna macrura.—Summer visitant, the predominating species, I believe, at the Ascribs, but less numerous probably than the Common Tern on Dunvegan Loch.[1] In 1884 I shot some in two localities, and obtained an equal number of each species; but in 1885 the Common Tern seemed to have nearly driven off the Arctic from Dunvegan Loch; so too in 1886.

Sterna fluviatilis.—Summer visitant, nesting on islands on the south coast of Skye, as well as on the north-west. The eggs are generally laid in a pretty substantial nest of dried bents in low heather or in a tuft of sea pinks, but some are deposited on the bare rock, or on a handful of dried sea ware. On July 14, 1885, I found a single nest in a situation new to me, *i.e.*, in the centre of a strip of *rushy* ground. Most nests contain *three* eggs or young when laying has succeeded.

Larus minutus.—Accidental visitant. Captain Cameron told me that he shot a little Gull, recorded by Mr R. Gray, in 1865.

Larus canus.—Resident, nesting on the Ascribs and islands in Dunvegan Loch.

Larus argentatus.—Resident, many pairs nesting on the broken precipices of Waterstein, and great numbers at Lowergill. A few breed on the islands in Dunvegan Loch.

Stanford University Libraries

eye to be of a creamy white, but my binoculars revealed the mottled wing coverts.

We landed, hoping to stalk it; but the whole company of Gulls rose again, and returned to the troopship, the Glaucous being again one of the last to rise, and departing leisurely, with slow, regular beats of the wing. It was shot by Shaw the same afternoon.

On July 10th, 1885, Shaw observed a similar Glaucous in Loch Pooltiel, but tried in vain to get a shot. He volunteered that it closely resembled the April bird, but was of a purer cream colour. We searched for it subsequently, but it had disappeared. In the following December two more immature birds haunted Dunvegan Loch, and the smaller bird was shot by Shaw.[1] On dissection, it proved to be a female, the stomach distended by the remains of small fish. A fine immature Glaucous Gull, which I have examined in the possession of Mr F. P. Johnson of Castlesteads, Brampton, Cumberland, was shot by that gentleman on Loch Bracadale in the winter of 1881-82, when "following the carcase of a dead cow." A similar but larger specimen was obtained at the same time and place. Captain Macdonald informs me that though he has met with the Glaucous Gull in Skye on several occasions, he considers that it is a very infrequent winter visitant. He observed a single bird at Waternish in the winter of 1881-82, and shot another at Stein in February 1886. Mr Dumville Lees has never met with it in Skye.

I did not hear the April bird utter any cry; but that of a pinioned bird at the Zoological Gardens may be described as a deep monosyllabic "bark," strikingly unlike the shriller cries of other *Laridæ*.

The *irides* of this bird, an adult, are pale yellow; those of the April bird being dark brown, and those of the December bird dark blue. *Tarsi*, toes, and webs are pale flesh-colour in all three specimens.

Larus leucopterus.—Casual visitant of rare occurrence. When driving to Hamar, November 29, 1883, we obtained a

[1] A large immature bird was shot at Miloveig, 31st March 1886, and proved to have been feeding on oats. Others were seen at Galtrigill, and a party wintered in the Sound of Harris (*fide* Sheriff Webster).

fine view of an adult Iceland Gull in a potato field, but not having a gun with us, could not secure the specimen. Mr F. Johnson shot one on Loch Bracadale in the winter of 1881-82, and Captain Macdonald has also met with it.

Rissa tridactyla.—Resident; numbers nidificating at a large station at Greshornish, others near Waternish, and many more at Eiste. In 1885, the fishermen pointed out to me a nest on which a Kittiwake was still sitting, on July 16th, adding that they had watched this solitary bird for three weeks without seeing her leave her charge.

Stercorarius crepidatus.—Irregular autumnal visitant, observed by Captain Macdonald and Mr Dumville Lees. Mr H. Macdonald also described to me the movements of a pair which he had observed at Portree plundering the Gulls. (I have seen it at Strome Ferry.)

Procellaria pelagica.—Summer visitant, nesting sparingly on one Ascrib Islet, where it is decreasing, owing to the increase of Puffins, which take possession of its burrows, and sometimes kill the proper owner. The one white egg is placed at the extremity of the burrow, and is incubated by one bird at a time, the other remaining at sea during the day. A few dry straws form the nest lining. In 1884, I took an egg on June 26th, which was quite fresh; the birds being special favourites of my host, Captain Macdonald, I

Stanford University Libraries

early autumn, though I have reason to believe that there are one or two nesting stations on the west coast of Skye. The evidence hereon is still incomplete, but I have repeatedly observed them under suspicious circumstances.

Puffinus major.—On July 13th, 1885, I found a dead specimen lying upon a heap of torn seaware among the rocks at Lowergill. All night long we had searched for the Manx Shearwater, but to no purpose. When day began to break, this interesting waif was descried upon the shore. Probably it had perished in the Minch, and had been blown ashore by a N.-W. gale on July 11th. The neck was so much torn, that it seemed best to macerate the specimen; and having no books of reference at hand (except the keeper's copy of John's "British Birds," with the woodcut of which the specimen agreed), I minutely compared the bird with two fresh skins of *Puffinus anglorum*, and took the following description of *P. major*:—bill, grey; lower mandible, paler; tarsi, 2.4; central toe, 2.9; colour of tarsi, toes and webs, pinkish white, a dark band shooting along the outer surface of tarsi and outer toes, and slightly mottling the webs; interior of mouth, pale grey; first primary, slightly exceeding second; wing measurement, exactly 13 inches. The demarcation between the dark-brown upper surface, and the white neck and lower parts, was very striking.

Alca torda.—Summer visitant, great numbers breeding on the ledges from Lowergill to Ramasaig.

Lomvia troile.—Summer visitant, approaching our coast in small numbers at the beginning of April, and breeding at Lowergill in denser throngs than *A. torda.*[1] In April 1885, I observed an individual on Dunvegan Loch, in which the upper parts were of a uniform cream or dun colour; and in the following July, I again saw a cream-coloured Guillemot in the Sound between Eigg and Arisaig. A similar variety is recorded by Mr John Cordeaux (*Zool.*, 1877, p. 298). [Feilden and Harvie-Brown have one in their collection.—J. A. H. B.]

Uria grylle.—Resident,—a *few* winter with us,—nesting in vast numbers at the Ascribs, where they nestle among the

[1] In 1886 I observed a Guillemot still in full *winter* dress off Oban on 25th June.

loose masses of rock upon the shores. There are small colonies at Ramasaig, Dunvegan Head, and Miloveig. I have often visited the latter colony, which inhabits the crevices of the basaltic cliff, where the rock has become detached by frost and weathering. The young are hatched in the last week of June, and are covered with greyish black down; the bill of a newly hatched downy nestling is nearly black; tarsi and toes, dark-purplish red; webs tinged with red. I shot a Black Guillemot, with *sandy* flight feathers, on Dunvegan Loch in 1884. A few breed off Tallisker.

Mergulus alle.—Rare winter visitant, occasionally observed off the Ascribs by Captain Macdonald. Dead specimens were taken to Captain Cameron; and Mr Dumville Lees has likewise met with it. A bird, apparently of this species, was captured on Fasach in the early spring of 1885, and released by J. Macraild.

Fratercula arctica.—Summer visitant, breeding in immense numbers at the Ascribs, where it burrows in the turf, or deposits its eggs under masses of rock. The young are hatched at the beginning of July, rather later than the Black Guillemot. *Martin* writes of FLADDA: "the Coulter-nebs are very numerous here; it comes in the middle of March, and goes away in the middle of August; it makes a tour round the Isle sunways before it settles on the ground and

Stanford University Libraries

the old birds had bred there again that season (1883), but that he had boiled and eaten the eggs.

Colymbus septentrionalis.—Winter visitant, occasionally observed by Captain Macdonald, who remarks, that no doubt this species formerly bred on a loch between Waternish and Greshornish, called in Gaelic, "the loch of the Red-Throated Diver." Partial to Dunvegan Loch in autumn.

Podiceps griseigena.—Casual visitant. A bird, in winter dress, was shot on the Skye coast by Captain Macdonald some years ago.

Podiceps auritus.—Casual visitant. A Sclavonian Grebe, in partial summer dress, was shot by Captain Macdonald on Dunvegan Loch one spring.

Podiceps fluviatilis.—Winter visitant, a few individuals constantly enjoying the shelter of the Skinidin Islands, to the land side of which five or six Dabchicks may be observed any forenoon. I had reason to believe that a pair nested at Loch Eishort in 1883, but was unable to fully verify the facts.

IX. *Notes on the Sucker Fishes,* Liparis *and* Lepadogaster. By W. Anderson Smith, Esq., Ledaig, N.B. Communicated by Mr J. T. Cunningham. [Plate VII.]

(Read 16th December 1885.)

The small species of shore fishes generically termed "Suckers" by the vulgar, have scarcely had that attention directed to them which their interesting character deserves. For some years I have watched their movements with care when opportunity offered, and endeavoured to obtain some data for a more complete life-history than has yet appeared.

The large species, *Cyclopterus lumpus,* has had more attention devoted to it; whilst I have not been able to furnish myself with local specimens to give it closer study, the ova having hitherto proved in my hands less amenable to indoor incubation than that of the many other fishes I have hatched out.

So many systems of nomenclature and descriptions exist, that for the sake of simplicity and uniformity I will follow

Dr Day, whose important and valuable work on British Fishes will probably remain our best authority for some time to come, despite the inadequate character of some of the illustrations.

Liparis vulgaris, the commonest species of *Liparis*, seems to be extremely rare in our district, where it appears to be superseded by its congener, *Liparis Montagui*. These latter I have taken mainly in Loch Linnhe. The species of *Lepadogaster* appear to monopolise the inner lochs, such as Loch Creran, where I have never taken a single specimen of *Liparis*.

On the other hand, the larger species of *Lepadogaster* is common in the same haunts as those frequented by *Liparis Montagui*, and the commoner of the two even there.

It is extremely difficult to account for the movements of these fishes. At one time they will be comparatively common under stones on a certain piece of foreshore at low spring tide; and again they may be searched for in vain even in the same season of the year. I have taken *L. Montagui* freely in March, full of roe quite ripe; and again, not a single one was obtainable in the best days of the best tides during the same month in other years. Nor could I account for their movements except on the ground of there being rough water outside or rough water inside; for although

Stanford University Libraries

as befits a sluggish fish finding its food on the ground, in the young is least prominent, in keeping with its more active and nervous existence. At this stage, also, the fins are represented by a continuous diaphragm, with indications of rays, all round from the anterior commencement of the dorsal fin to the anus (Figs. 4 and 5). This character is lost in *L. Decandolii;* but according to Day, it distinguishes *L. Gouanii*, although this species, as figured in Couch under the name of *L. Cornubicus*, has no such continuity of fins—the dorsal, caudal, and anal being all sufficiently clearly defined. As the specimens figured in Day came from the Channel Islands, while that of Couch was drawn directly in Cornwall, it may possibly be that another species exists in the South without the continuous fin around the caudal, as we can scarcely imagine Couch figuring this, to him the best-known and most familiar species, with such a marked characteristic as the continuity of the fins misrepresented.

Lepadogaster Decandolii of Day is well figured as the Connemara Sucker of Couch, the two first figures being females, the last a male. This led Couch to suggest two species, owing to the marked difference in appearance between the sexes. My attention was first called to this, by finding, in March 1883, a pair of these interesting Suckers under nearly every stone I lifted on a stretch of rough boulder-clad foreshore on Loch Creran. These were so distinct in appearance, and so affectionate and attentive to each other, that I decided they must be male and female, more especially as they had a "lump" of ova in most cases alongside.

Yet my deduction from the presence of ova was quite wrong, for these were the ova of *Centronotus*, which are pale and opalescent, while the ova of *Lepadogaster* are spread evenly on stones or shells, and are of a fine pinkish tinge. These numerous pairs were consequently merely sheltering there until the return of the tide, and were occupying their customary haunts. As the usual months for throwing their ova are June and July, it is clear that they pair early, if indeed they are not monogamous and constant in their affections.

In the month of June last I took two several pairs, and placed them in dishes of sea-water in the house, at a time

when I considered they ought soon to be spawning. Each pair was placed separately — one pair being a couple I had found together, the other a male and female taken from separate stones at some little distance apart. Next morning, the 14th June, the females had deposited their ova, in both cases on pieces of slate I had placed for the purpose. In both cases, also, the eggs were fecundated, with very few exceptions, showing that, however they may pair and remain faithful, a ripe male will fecundate the ova of a casual companion.

The ova when deposited were pale pink granules of comparatively large size, laid on the slate with less regularity than in the case of *L. bimaculatus*, and the parents seemed to lie on the top of them with most watchful anxiety. In order to keep them free from dust and sediment—the great enemies of ova when thus kept under unnatural conditions, and merely supplied daily with fresh water—the slates were turned upside down, under which circumstances the parents were for some days almost invariably found upside down upon the ova, attached to the slate by their suckers.

Finding it difficult to supply such small fishes with satisfactory food, I kept the dishes supplied with bunches of the finer-tufted seaweeds, amid the numerous branchlets of which minute crustacea and mollusca, both mature and embryonic,

Stanford University Libraries

than *Lepadogaster bimaculatus;* and the latter is, again, more active and vigorous than *L. Decandolii.* I have scarcely ever taken the ova of *L. bimaculatus* except arranged in regular layers within the empty shells of Scallops (*Pecten opercularis*). Even after the ova have been hatched, the shell retains the impression of the eggs as originally deposited. The ova of this fish I have brought out frequently from the shells, but have never had it deposited in captivity. The eggs are generally accompanied by the parent, curled up inside the shell, watching over the progress of her progeny; and if the dredge should bring up a shell thus supplied with ova from eight or twelve fathoms off scallop ground, if the fish is not in the shell it is almost sure to be in the other contents of the dredge, showing it had either come out in the capture, or been watching close by.

These captures from scallop ground are frequently of great brilliance and beauty, varying greatly, probably according to the ground, and passing from pale orange pink to the most brilliant crimson. Certain of them are entirely without the distinguishing two spots, whence their secondary name is derived; and these are otherwise generally the most brilliant in colouring, and the most delicately organised. Shore-fish —taken at low water, as they are occasionally—are not commonly of so refined an organisation, or so gracefully delicate, as those from the scallop ground.

Liparis Montagui frequents stronger waters, and probably also in consequence warmer waters, than *Lepadogaster* as a general rule, and spawns in March; while both our species of *Lepadogaster* spawn in June and July. The eggs of all are large compared with the fish; and this may be said as a rule of shore-fishes whose ova are comparatively few in number, and more carefully watched over and tended by the parents. The eggs, indeed, of *Lepadogaster* may be readily counted, and average about 150.

Within a very few hours after fecundation, the ova that have been fecundated are easily distinguishable by the naked eye from those that are barren; and Fig. 1 shows them on the fourth day distinctly marked. On the thirteenth day the circulation is readily noted, and the eyes are almost as

brilliant as the ocelli of the *Pectens.* This is a feature in most fish embryos. The eyes of these fish, however, continue to increase in brilliance and beauty until they become a distinguishing feature in the little creatures. The golden inner iris of the female is more especially vivid.

In the species of *Lepadogaster*, the embryos show a marked irregularity of position; that is, the eggs are affixed to their station regardless of the future growth, which may develop with its head or tail in any direction with reference to the place of attachment.

This also is observable with regard to other embryos, some capsuled ova developing with the head downward, others with the tail end affixed.

One difficulty met with in investigating the embryology of these fishes lies in the tenacity with which the ova stick to their place of attachment, no instrument I could invent removing them without fatal injury. This narrowed my investigations in some stages down to the points that could be examined through a pocket lens, and prevented more careful microscopic drawings.

At eighteen days, however, the young of *Lepadogaster Decandolii* showed marked indications of approaching the active stage, although the sac was still of great size, and the attachment to the slate too secure to be safely broken. Not

Stanford University Libraries

Now, seeing *C. lumpus* grows to the length of 24 inches, and 3 inches may be considered the full development of *L. Decandolii*, we should have had the latter furnished with a developed sucker at about 3 mm., or say one-half the size at which it arrives without a show of disc. I have not had an opportunity of watching the development of the disc of *Liparis Montagui;* but from its formation I should predicate an early development, as in the case of *C. lumpus*, to which its disc is allied.

It would appear as if a slender body and weak vertebrate system had developed, in the case of *Gobius* and *Lepadogaster*, a habit of clinging to the seaware and sea bottom that stimulated the pectoral region to meet the necessities of the situation, and, in the case of *Lepadogaster*, to cushion itself, the pectoral fins curving around the swelling bosom of the fish. Between these cushions depressions were left, and these proving very advantageous to the fish by their sucker action, the advantage was pursued by nature, and transmitted. In the case of *Gobius* (Fig. 9), the cupping action was wholly performed by the fins, the rays of the pectorals strengthening and stiffening, the better to meet the difficulty. This is much inferior to the true suckers in effect, the *Gobius* being upon the whole an active race, and frequenting less exposed situations. They have, indeed, become partly fresh and brackish water fish, and their suckers are so far makeshifts.

Although the small cushion-like discs of *Cyclopterus* and *Liparis* are the truest suckers, yet the species of *Lepadogaster* are perhaps the most truly sucker fish. This especially applies to *L. Decandolii* (Day), which is really a sucker fish all the way forward from the sucker proper itself. Two-thirds of its length, and practically three-fourths of its weight and horizontal surface, is a sucker. By sucking up its lower jaw, and allowing its cartilaginous framework to rest on any object, the front jaw adds its sucking action to the sucker proper. This is aided by the plentiful discharge of mucus, in which this species emulates the Unctuous Sucker, *L. linearis.*

The sac of *Lepadogaster Decandolii* was quite absorbed

just six weeks after the deposition of the ova, and a fortnight after it had left the attachment of the slate; and yet, except the appearance of muscular nuclei indicated in Fig. 6, no sign of a disc was perceptible.

No brush can give any adequate conception of the brilliance of *L. bimaculatus* from eight to twelve fathoms on scallop ground; or the vividness of colouring of the male of *L. Decandolii* in the breeding season. The prevailing tone of this fish is a somewhat sober-tinted combination of olive-greens and greys. At the breeding time the female is much smaller, less conspicuous in every way, and commonly marked with a band across between the eyes, which somewhat resembles the spectacle mark on the Cornish Sucker of Couch —*L. Gouanii* of Day. More timid, more active, slighter built, and more sober-tinted, the female might well have been supposed to be a different species from its brilliant companion, whose bright carmine spots on the dorsal fin commonly give him a sufficiently distinctive appearance.

The spectacle mark shows under the lens as being made up of bright scaly particles, distinct from the mucous-coated skin of the remainder of the fish. Its gelatinous consistency causes the fish to display its emotions with the facility of a cuttle-fish, and the colour consequently changes with the utmost readiness, forming in these as in most

Stanford University Libraries

Explanation of Plate.

Fig. 1. Ova of *Lepadogaster Decandolii* (Day), attached to piece of slate; natural size.

Fig. 2. Ovum of same fish, fourth day after fertilization; *a*, oil globule; magnified.

Fig. 3. Thirteen days after fertilization, blood circulating, and somites visible.

Fig. 4. Young fish, hatched 14th July, sketched 26th July, 1885; length, ¼ inch.

Fig. 5. Same stage, magnified.

Fig. 6. Ventral surface sixteen days after hatching.

Fig. 7. The ventral sucker of the mature fish.

Fig. 8. Sucker of young *Cyclopterus lumpus*, 1 inch in length.

Fig. 9. Sucker of *Gobius* formed from ventral fins.

Fig. 10. Sucker of *Liparis Montagui*.

X. *The Sense of Touch in* Astacus. By G. Lovell Gulland, Esq., M.A., B.Sc., M.B., C.M. [Plates VIII. and IX.]

(Read 16th December 1885.)

Introduction.

The following is an account of the principal papers in which the sense of touch in the Crustacea and allied forms has been discussed.

The latest writer (if we except the ordinary text-books) who approaches the subject of the sense of touch in *Astacus*, or indeed in any of the higher Crustacea, is Huxley, who [1] suggests that the "setæ, so generally scattered over the body and appendages, are delicate tactile organs;" and then goes on to point out the likelihood that they are in some way connected with nerves. We shall see how this opinion has arisen.

De Morgan [2] sums up the literature of the subject up to his time, and suggests that the tufts of bristles on the large claw of the lobster are tactile in function. He traces the nerve-fibres to a point near the bases of the setæ in the "flabellum" of the tail of the prawn and propodite of the claw of the shrimp, but makes the mistake of supposing that

[1] The Crayfish, p. 113.

[2] On the Structure and Functions of the Hairs of the Crustacea, Phil. Trans., 1858.

the granular matter inside the setæ consists of "nerve-granules." He does not seem to have experimented at all on their function, and for him all setæ are tactile.

Leydig, in 1860,[1] besides describing the so-called olfactory setæ, mainly in Daphnidæ and Phyllopods, says, talking especially of the antennules of Asellus, "besides those hairs which have the nature of simple outgrowths of the integument, and stand with their root over a cuticular canal, where, through a continuation of the matrix, one might say a papilla rises towards the hair," these "possess also 'Tastborsten,' *i.e.*, simple pointed or feathered hairs, which at their base are connected with a nerve-ending." He gives, however, no account of the minute structure or distribution of the setæ, or of the structure of the nerve-ending, nor do his figures give us any assistance. In his "Lehrbuch der Histologie" (Fig. 113), he shows the connection between nerve and setæ in the larva of *Borethra plumicornis*, but to this we shall return later.

Hensen, in his admirable paper,[2] touches upon the relations of the auditory setæ to others, and to him also is due the credit of establishing the exact nature of the connection between nerve and seta in the auditory setæ.

Dr W. C. M'Intosh[3] gives a very elaborate account of the variations of the setæ in that species, but his researches are

Stanford University Libraries

joint, one much larger than the rest; and he figures the approach of the nerve to it with a very low power.

Lemoine[1] was the first to investigate the subject from a physiological standpoint. By the use of forceps, percussion, needles, and stimulation by electricity, he finds that certain parts are more sensitive than others (to these I shall refer in the course of this paper), but only in the case of the antennæ, antennules, and the "limbs" has he supplemented these observations by microscopic examination; and here he finds setæ "straight, cylindrical, tapering at their extremity," which he associates somewhat tentatively with the sense of touch, and which, though he does not figure them, must, from his description of their structure and position, be identical with the setæ which I recognise as tactile.

Braun[2] describes incidentally two kinds of setæ in the crayfish, identical with those which I recognise, and gives their distribution in a general way; but any consideration of their physiology is foreign to his purpose, and he does not enter into it.

Claus[3] recognises that the feathered setæ, "Fiederborsten," are merely rowing organs—"Ruderborsten"—but says that the short and simple spines are touch-organs, and possess an "axial-thread" in their striated contents; to them runs a nerve, which is provided with a ganglion-cell, and, passing between the matrix-cells, becomes continuous with the axial-thread ("Achsenfaden"). He does not figure this arrangement with a high power in any of the Argulids, but gives a drawing representing a similar arrangement in *Sida*, which I reproduce (Pl. VIII., Fig. 9).

I cannot accept the view of the nerve termination which regards it as running quite to the end of the seta, for not only do my own positive observations, as well as those of Hensen and others, directly contradict it, but the whole history of the formation of the setæ and the phenomena at the moult, as given by Hensen and Braun, go to prove its

[1] Rech. pour servir à l'histoire des systèmes nerveux, musculaire, et glandulaire de l'Écrevisse, Ann. des Sciences Naturelles, Serie 5, tome ix., 1868.

[2] Ueber die histologischen Vorgänge bei der Häutung von Astacus fluviatilis, Arbeiten aus dem Zoologischen Institut zu Würzburg, ii., 1875.

[3] Entwicklung, organisation und systematische Stellung der Arguliden, Zeit. f. wiss. Zool., 1875, pp. 240, 241.

falsity. I shall again have to speak of the actual nature of the contents of the setæ.

Leydig, again, writing in 1877,[1] in describing the antennæ of Gammarus, enters at some length into the question of the functions of the various forms of setæ in this and other Crustacea. He describes and figures somewhat roughly, as "gewöhnliche Borsten," setæ closely resembling the tactile setæ in *Astacus;* but in opposition to De Rougemont, whom (p. 230) he quotes, and who regards these as tactile setæ, Leydig accepts the second variety—the "Fiederborsten"—as tactile, and adduces in evidence his own and Weismann's researches on the larva of *Corethra plumicornis.*[2] I shall have more to say on this point when discussing the relations of the various forms of setæ.

Vitzow[3] offers incidentally some remarks on the setæ.

Jourdain's paper[4] need only be mentioned to call attention to the fact that on p. 417 he talks of the "different varieties of setæ considered to be tactile."

As regards other Anthropods, I may cite Jobert, who[5] devotes a small portion of his paper to the tactile apparatus in the mouth-parts of various insects, and shows that there are tactile end-organs very similar to those I am about to describe. He seems, however, to have misunderstood the nature of the connection between the end-bulb and the

Stanford University Libraries

Of these older writers, the papers of Leydig and Weismann on the larva of *Corethra* already cited, and Leydig's papers,[1] are especially worthy of notice, but the want of physiological confirmation detracts very much from the value of all these contributions. I shall again have to refer to Grobben's paper[2] and to Studer,[3] and so content myself at present with mentioning them.

The tactile nerve end-organs which have so far been studied in the Crustacea have been the simple forms, which are found in the lower members of the group; the mode in which the nerve-fibre is connected with the seta had not been satisfactorily made out, and there was a tendency to regard the nerve as passing to the end of the seta; the distinction between the various forms of setæ was imperfectly known, as was also the relations between those of higher and lower forms; and the distribution of tactile setæ had nowhere been ascertained clearly.

[I can only mention Professor Leydig's interesting paper (Die Hautsinnesorgane der Arthropoden Zool. Anzeig. 222, 223, May 1886), and regret that I cannot agree with his view of the contents of the tactile setæ. It seems to me that the mode of formation of these setæ, as well as direct observation of the facts, quite excludes the possibility of the contents being nervous in character.]

Forms of the Setæ on the Exoskeleton of Astacus.

As Braun (*loc. cit.*, p. 131) has already pointed out, these may be divided into two main groups, according to whether the lumen of the seta communicates with the canal through the integument over which it stands or not. Those in which there is this communication seem in every case which has been examined to be in connection with a nerve-fibril, and may be called "*sensory setæ*," and, according to the peculiar form of sensory impression which they are modified to re-

[1] Zur Anatomie der Insecten, Reichert und Du Bois Reymond's Archiv für Anatomie, etc., 1859.

[2] Ueber bläschenförmige Sinnesorgane und eine eigenthümliche Herzbildung der Larve von Ptychoptera contaminata, Sitzb. d. Akad. d. Wiss. zu Wien, Bd. lxxii., 1875.

[3] Nervenendigungen bei Insecten, Mitth. der Berner Naturforsch. Gesellsch., 1873.

ceive, may be divided into tactile, auditory, and olfactory setæ.

Those whose lumen is closed, and to which no nerve can be traced, may be called "*fringing setæ*," from the fact that they mainly form the fringes which are found on so many of the appendages and segments of the body. I do not propose to discuss in detail the structure of the olfactory or auditory setæ, and shall therefore pass at once to the consideration of the tactile setæ.

Tactile Setæ.—These setæ, whose distribution will be discussed in detail, vary slightly in length and thickness in different parts of the body, and are perhaps seen to most advantage on the terminal segments of the abdominal swimmerets. Here they are many times longer than their breadth, cylindrical, simple (*i.e.*, without secondary bristles), hollow, with the lumen about as thick, in optical section, as one of the walls, and sometimes with a few granules in the interior; forming a cylinder of the same thickness from the base to a point whose distance varies from a quarter to a half of the way up, where there is an internal thickening of the wall all round, and an appearance of jointing. According to Braun (*loc. cit.*, p. 149)—and I see no reason to doubt the correctness of his observations—this corresponds to the point at which the seta is doubled on itself before the moult (*see* his

Stanford University Libraries

the formation of the new seta, and, as Braun (*loc. cit.*, p. 151) points out, is drawn out with the seta in the process. Under no circumstances is there any "nervous matter" in the lumen.

The setæ are uncalcified, chitinous, and very elastic, which is due partly to their own substance, partly to the joint which connects them with the integument. They are bright yellow in colour, and the stouter and thicker their walls, the more this is marked, so that it is probably due to the actual colour of the chitin. Sometimes, especially when the setæ are thick and strong, there is an appearance as if the wall were double, which is indicated in Pl. VIII., Fig. 1. The manner of their articulation to the integument is peculiar, and differs slightly from that of the fringing setæ. The lumen is widest at the base, as a general rule, and the walls thickest; suddenly the thick cylinder formed by the walls widens out, and the walls become thinner and more membranous, and roof in a dilatation of the canal which pierces the integument; while the membrane itself passes up to become continuous with the cuticular thickening or "areola" which surrounds the base of the seta, and rises slightly above the level of the cuticle.

This will be better understood by reference to Pl. IX., Fig. 12. The main use of the dilatation of the canal under the setæ is evidently to allow the base of the seta, which is slightly sunk in the dilatation, to move freely. There are slight variations in the forms of the setæ, the most noticeable being an occasional very minute serration of the distal portion, whose morphological significance will be noticed elsewhere.

Fringing Setæ.—These likewise vary slightly in their degree of development in different parts, but are also best seen on the swimmerets. Their most essential characteristics are the absence of any connection with nerves, and the closure of the lumen near the proximal end of the seta by a thick chitinous ingrowth; this, according to Braun (*loc. cit.*, p. 151), is not present immediately after the moult, but is formed by the new "papilla." In connection with this, it is interesting to notice that in Thysanopoda the fringing setæ are not

closed, but that their lumen communicates freely with the canal over which they stand; this seems to indicate that the closure of these fringing setæ is of comparatively recent appearance among the Decapods, supporting the views of Boas,[1] who, while he separates *Thysanopoda* and the other Euphausidæ from the Mysidæ and Lophogastridæ, and regards them as the most primitive forms of the Malacostraca, still considers that they are not very far distant from the *Decapoda natantia*, to which again *Astacus* is one of the most nearly allied forms among the *Decapoda reptantia*. Beyond the point of closure, where they are nearly cylindrical, these setæ are flat and band-like, so that in a cross section they have the form of an elongated rectangle with the corners rounded off. From the anterior and posterior flat surfaces no bristles arise, but on each of the two edges there is a single row of very delicate secondary bristles, which are solid, and the longest of which are about 0·2 millimètres in length, and between 0·001 and 0·002 millimètres broad at the base. The wall of the primary seta, except at the base where it is thick and strong, is much thinner than that of the tactile setæ, and on the edges has a curved outline, the depressions in which correspond to the points of insertion of the bristles, while the side towards the lumen has projections which correspond to these depressions (see Pl. IX. Fig. 13). The

Stanford University Libraries

The closure of the lumen takes place at a point about 0·03 mm. above the articulation with the integument, by means of a chitinous plate about 0·006 mm. thick, which passes right across the lumen. As the canal on which they stand is relatively much wider than that of the tactile setæ, the hypodermis passes up nearly as far as the closing plate; and this seems to confirm Braun's suggestion as to its formation. The articulation differs slightly from that of the tactile setæ, inasmuch as the membranous part is not so long; the "areola" is more delicate and nearer the base of the seta, and the whole is raised on a sort of pedestal formed by a projection of the integument.

These setæ vary considerably in details, but the type is always recognisable. Sometimes the bristles are only found on the distal part, or the seta is not quite so flat as I have described it, and the setæ are arranged more irregularly, and so on.

Distribution and Physiology of the Setæ.

The only writer who has attempted to examine the function of the setæ experimentally is Lemoine, and he has done no more than commence the study, and has in addition made but few and imperfect microscopical observations. I shall now explain the grounds which led me to regard as tactile those setæ to which I have already ascribed that function.

I examined first the antennæ, since they have always been regarded as peculiarly sensitive to tactile impressions, but found that though the animal evidently assumed an attitude of watchfulness, and showed some disquietude when I rubbed the surface of the antenna or twitched it, yet that there was no immediate response, and that, moreover, the setæ were so small and so thinly set, that it was impossible to say whether the impression was received by them or by the general surface. I then turned to the great claws, where in the "hand," with the naked eye, it is perfectly easy to distinguish delicate transparent projections, especially numerous along the inner edges of both the dactylopodite and the "index" or "anvil" of the propodite, which, with a low magnifying power, resolve themselves into tufts of setæ.

These have already been recognised by Lemoine and Huxley in the crayfish, and by M'Intosh in *Carcinus mænas*, and are usually recognised in systematic descriptions of Crustacea. It is quite possible to introduce a needle between the pincers without the creature taking any notice of it, but as soon as one of the tufts is touched, no matter how gently, the pincers close at once with a snap more or less decided according to the vigour of the animal, the strength of the impression, and the number of tufts touched. If the tubercles on the pincers be touched, there is no result so long as the tufts of setæ are not pressed upon. On examining the tufts with higher powers of the microscope, I found that they were composed of setæ of the type which I have already described as tactile, and the "index" of the propodite was also specially suited for demonstrating the connection of nerves with the setæ.

From these data I considered myself justified in assuming that these setæ were specially adapted for touch, and proceeded in a similar way to make a detailed physiological and microscopical examination of the setæ of the surface of the body.

The Eyes.—On no part of either the peduncle, the surface of the eye, or the membrane between the eyes, are there setæ of any kind. It will then, at first sight, seem strange that, if the peduncle be touched, the eye is drawn back under

Stanford University Libraries

of which are directed forwards; they are of the usual type, but very small, often not exceeding 0·1 mm. in length. On the two or three most distal segments, where the olfactory setæ are absent, the tactile setæ are longer and more numerous, and they are most numerous on the last segment. On the endopodite the arrangement of the tactile setæ is the same, but here they are rather longer. On the third joint of the main stem there is one large group of tactile setæ on the outer margin at the base of the exopodite, and one or two isolated setæ near it; on the inner margin is a row of fringing setæ, and all the setæ on the first and second joints are also of this kind, with the exception of a very few small tactile ones on the inferior margin of the triangular first joint. If the antennule be examined *in situ*, the significance of this arrangement will be at once apparent; for it will be seen that only those parts which bear tactile setæ are really external, and that these only could receive tactile impressions, since the other parts are covered by the eyes, the rostrum, squame of the antenna, and the antennule of the opposite side. The fringing setæ along the margins of the surface, which bears the opening of the auditory sac, as well as the close set row of fringing setæ which cover the opening, act, doubtless, as strainers, and prevent the entrance of foreign bodies to that delicate organ.

Experimental.—Lemoine has already remarked that the antennules are extremely sensitive, especially at the point, and this I can fully corroborate. As Huxley (*loc. cit.*, p. 115) has pointed out, the olfactory setæ are of essentially the same structure as the tactile setæ; Jourdain's denial of this resemblance (*loc. cit.*, pp. 405, 409) is due to an erroneous conception of the structure of the olfactory setæ, and ignorance of their mode of formation. I shall have more to say of the olfactory setæ when discussing the genealogy of the various forms of setæ.

The Antennæ.—On the terminal multiarticulate filament of the endopodite (Huxley's procerite), the disposition of the setæ, which are all tactile, is just the same as in the filaments of the antennules; they are, however, more numerous, and near the base of the filament rather longer. There is a large

tuft of tactile setæ at the base of the procerite, and a few are continued from that point down the outer margin of the carpocerite; but all the setæ below that point on the upper surface are fringing setæ, as that part is covered by the antennules and the squame. On the squame there are only fringing setæ, very long and strong, arranged in a single row along its inner margin, and which evidently serve merely to increase the surface. On the under surface of the basal segments of the antenna there are no setæ.

Experimental.—According to Lemoine, the point of the antenna is very sensitive; this I am able to confirm. The rest of the procerite is sensitive, but not nearly so sensitive as the antennules. It seems strange, at first sight, that the setæ on the "feeler," as it is so often called, should be small, —and I may remark, in passing, that on the antennæ of the lobster they are still smaller,—but when we consider the amount of rough usage which the antennæ have to go through, it is evident that, if the setæ were longer and the proportion of breadth to length therefore less, they would be more fragile and in constant danger of mutilation.

Mandibles.—On the great coxopodite there are only a few short tactile setæ on the posterior margin, and a few fringing setæ on the ventral surface. On the palp, all the setæ on

Stanford University Libraries

stouter than on any other part of the body; in the 2d maxilla they are longer, and approach more nearly to the ordinary type. The setæ on the palps, between the laciniæ and round the edges of the scaphognathite, are fringing setæ, which show various modifications.

If the three pairs of appendages just spoken of be examined *in situ*, it will be noticed that the tactile setæ here, as on all other parts of the animal, are only present on external surfaces, where they can be of use. From the position of these appendages it is impossible to get at them for experimental purposes in the uninjured animal, or without touching other sensitive parts.

1*st Maxillipede* (1st thoracic appendage).—The tactile setæ are ranged along the inner edge of the lacinia interna (coxopodite) and the lacinia media (basipodite), in the latter alone, in the former with a considerable admixture of fringing setæ. On the rest of the endopodite and the exopodite there are only fringing setæ.

2*d Maxillipede* (2d thoracic appendage).—The arrangement of the tactile setæ is very similar to that on the 3d maxillipede, while on the 1st it closely resembles that of the maxillæ. The tactile setæ are numerous, and are mainly found in the fringe that runs along the inner edge of the endopodite. Here they are long, strong, and thickly set, and stand in several rows. On the basipodite and ischiopodite there are no fringing setæ, but on the meropodite and succeeding segments there are some curiously modified fringing setæ, very similar to those which M'Intosh describes as occurring on the maxillipedes of *Carcinus mænas*, whose secondary bristles are short, thick, and elliptical in form, and are placed, not at opposite edges, but both at the extremities of one surface (Pl. VIII., Fig. 8). On the tip of the dactylopodite are some very thick and short tactile setæ similar to those on the 1st maxilla. A large tuft of tactile setæ springs from the external edge of the propodite, but otherwise that margin is free from setæ. There are a few tactile setæ scattered over the exopodite.

3*d Maxillipede*.—The tactile setæ are arranged here in much the same way as in the foregoing limb. The ischio-

podite is the longest segment, and on it the setæ are placed ventrally (in the normal position of the animal) to the true edge, which is formed by a row of sharp tubercles. From the meropodite onwards the same modified fringing setæ are present, as on the 2d maxillipede, but on the dactylopodite the tactile setæ are all long and slender. On the external margin of the more distal segments are a few tactile setæ arranged irregularly. On the ventral surface of the appendage are a good many small groups of tactile setæ, and on the exopodite are a few setæ scattered here and there.

Experimental.—If the rows of setæ on the ventral surface and inner edge of the 3d maxillipede be touched, these gnathites on both sides are at once brought together, and the great claw and the ambulatory limbs are brought down towards the ventral surface. The exopodites of the 2d and 3d maxillipedes are also slightly sensitive. It is interesting to notice that the 3d maxillipede, which covers in all the other jaws and jaw-feet, is especially well furnished with tactile setæ, while on those appendages internal to it, merely the road to the mouth is lined with tactile setæ.

Metastoma.—The single row of setæ on the inner edge are delicate fringing setæ; there are no tactile setæ.

Stanford University Libraries

generally rather straighter than those, for instance, on the abdominal appendages.

Outside most of the groups of setæ, and standing slightly apart, are to be seen one or two fringing setæ, whose loss of function has caused a peculiar modification. They are shorter than the tactile setæ (Pl. VIII., Fig. 2), cylindrical, with walls much thicker than in the normal fringing seta; have their lumen closed, are rounded off at the tip, and have their secondary bristles twisted and twined round the main stem of the seta, so that they look like fringing setæ which have endeavoured to become tactile, but by reason of the closure of their lumen, and their having been already too much specialised in another direction, have failed to do so. Their presence is interesting, inasmuch as it illustrates the evolution of what was originally a swimming appendage into a tactile limb.

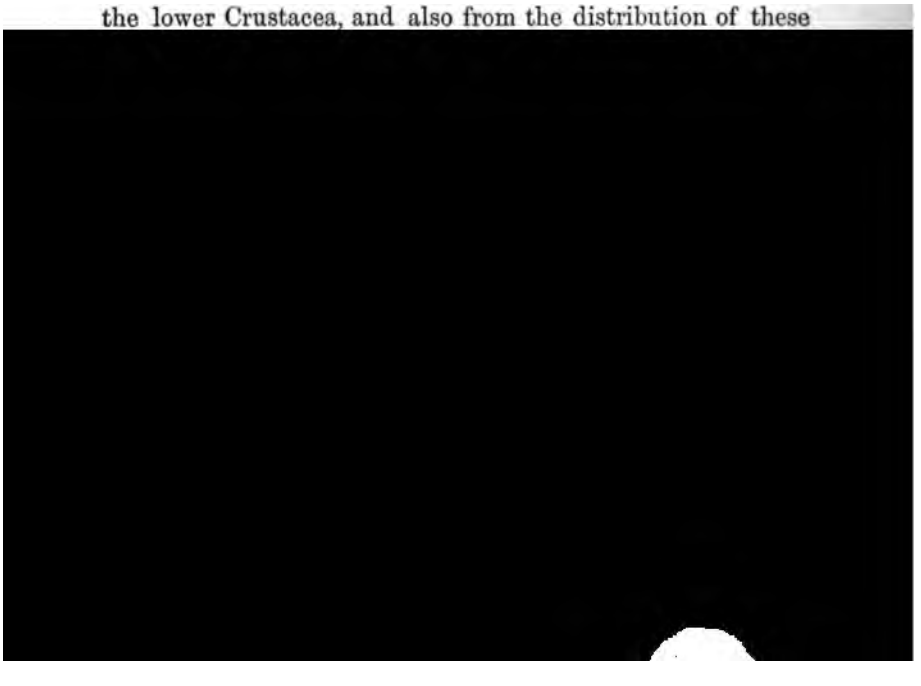
These groups of tactile setæ are especially large and numerous towards the tip of the "pincers;" there are a considerable number along the outer sides of both joints of the "hand," and a few small groups are scattered over the surfaces, being more frequent on the rough surface, which is usually turned upwards and outwards, and less frequent on the smoother inner surface. On the carpopodite the arrangement is similar; on the meropodite the setæ are almost confined to the two serrated edges; on the ischiopodite and basipodite there are a few very fine setæ, and very few also on the dorsal surface of the coxopodite. On the ventral surface of the coxopodite, however, the tactile groups are numerous, especially on the proximal side of the articulation with the basipodite. The setæ which Huxley (*loc. cit.*, p. 78) calls "coxopoditic" setæ, and which project into the branchial chamber, as well as those on what he calls the "base of the podobranchia," are merely fringing setæ peculiarly modified; they are longer and more delicate, and have their secondary bristles thicker and at greater intervals than the normal fringing setæ.

The description of the arrangement of the setæ given above applies perfectly to the 5th, 6th, 7th, and 8th thoracic appendages (two lesser claws, two posterior ambulatory legs);

it is only to be noticed that in the less modified claws of the 5th and 6th limbs the arrangement of the tactile groups is not so definitely marked along the edges as in the great claw;[1] the tufts are large and scattered irregularly over the surface of the pincers. On the spikes terminating the 7th and 8th limbs the arrangement is the same as in dactylopodite of the 5th and 6th.

Experimental, etc.—The effect of touching the tufts on the pincers of the great claw has been already described, and will be further entered into in discussing the nervous apparatus; suffice it here to say, that the result of touching the tufts in the lesser claws is precisely the same as in the great claw. If the sensitive surfaces (see above) of the meropodite or carpopodite of the great claw be touched, both the small claws endeavour to seize or sweep away the offending object, and the great claw is moved backwards as a whole in the attempt to seize it. The ventral surfaces of the coxopodites of all these limbs are sensitive, and if they be touched, all the thoracic limbs, with the exception of the maxillipedes, turn their points inwards, and endeavour to reach the object which is attacking them.

The aggregation of the tactile setæ into tufts is interesting, and, from the fact that it has not been described in any of the lower Crustacea, and also from the distribution of these



Stanford University Libraries

In the thoracic appendages of *Thysanopoda*, which all function as swimming feet, the tactile setæ, which are long and slender (*see* Pl. IX., Figs. 14 and 15), are found only on the tip of the last joint and the anterior margin of the two last joints (of the endopodite). There are no tactile setæ on the exopodite or the abdominal appendages, which all function purely as swimming feet.

Cephalothoracic Carapace.—The only setæ on the surface of the carapace are the exceedingly minute ones mentioned by Huxley ("Crayfish," p. 239), which are to be found on the lateral surfaces projecting forwards from the anterior part of the base of the large tubercles which stud the carapace in that region. They occur singly, are very small, and, as far as can be made out, have the characters of the tactile setæ; but since in all the spots where the setæ are undoubtedly functional, and where the cuticle is as thick as it is here, they occur in groups, and since these setæ are so very small and are practically protected from all outside influences by the tubercles, I greatly doubt whether they receive tactile impressions, and whether they are not to be regarded as a degenerate form of the tactile setæ. It is not difficult to understand why the cephalothoracic carapace should be without any definite tactile apparatus on its dorsal surface when we remember that the carapace is an outgrowth from the head-segments for the protection of the important organs situated in the thorax, and has, morphologically, no connection with the parts which immediately underlie it, and when we further consider that the whole of it is within the sweep of the antennæ, which, when intact, reach as far back as the second or third abdominal somite. At the anterior and inferior part of the carapace, however, the setæ are larger and more numerous, and probably functional. When the crayfish has its back protected in any way, its antennæ are directed forward, but when its dorsal surface is unprotected the antennæ are turned back and lie along its sides.

Round the margin of the carapace, and arising slightly beneath and behind its edge, is a single row of "fringing setæ;" on the dorsal surface, where the carapace overlaps the first abdominal somite, they are shorter, and the

secondary bristles fewer and smaller; on the ventral surface they are very long and slender, and there are no bristles on the proximal half of the stem. Those hairs on the carapace which fringe the orbit are of the same nature. In this situation they function evidently as a sifting apparatus, to prevent the entrance of any large foreign bodies, especially where they overhang the bases of the thoracic appendages and fill up the slight interval between these and the margin of the branchiostegite; and, while they admit of the free ingress of water to the branchial chamber, they bar the way to any organisms or inorganic particles that are not of microscopic size.

Experimental.—The carapace is impervious to tactile impressions, as it is modified for protective purposes, and the antennæ take the place of tactile setæ.

Dorsal surface of Abdominal Somites.—The dorsal surface of the first two somites, which are still within the reach of the antennæ, are almost entirely free from tactile setæ; but each succeeding segment has a greater number of groups of tactile setæ, precisely similar to those in the great claw, but as a rule, with fewer setæ in a group—averaging from six to twelve. They are directed backwards, and lie at an acute angle with the surface of the cuticle; they are most numerous on the surface of the telson. There are no tubercles on these

Stanford University Libraries

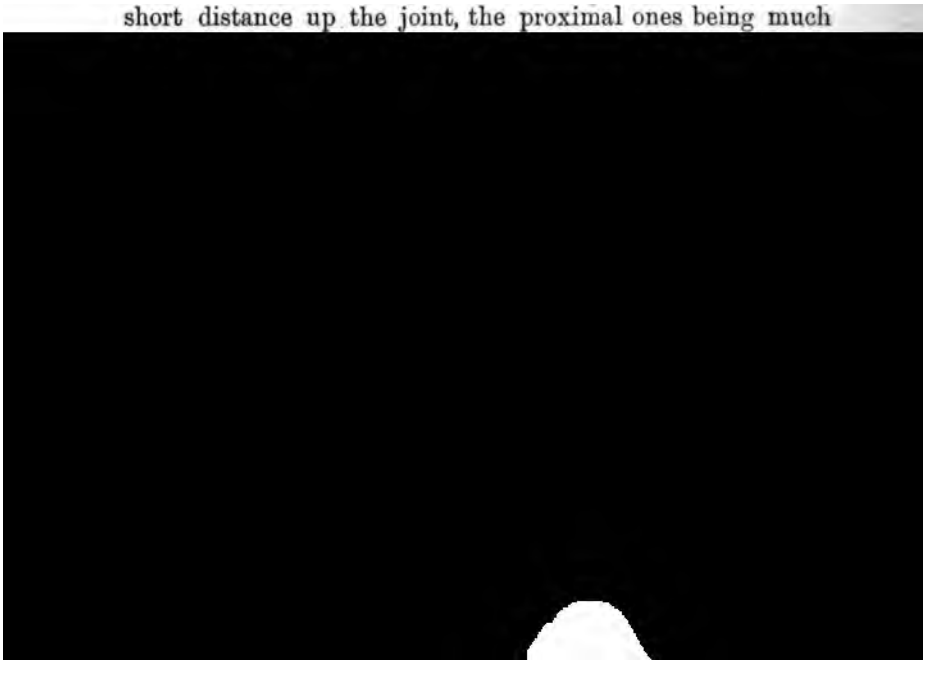
posterior margins of the pleura there is a slight re-entering of the angle, and from this depression—that is to say, on the very edge of the free margin above and exterior to the fringing setæ—springs a single group of very stout tactile setæ, generally not exceeding six in number.

The Caudal Fan.—By this name we may speak of the swimmerets of the 6th pair and the telson, and here we find a very great development of the tactile setæ. Taking the telson as an example, we find at the posterior margin an irregular row (perhaps really two rows) of fringing setæ, which are very long and strong, and dorsal to them, and therefore exterior when the abdomen is flexed or semiflexed, two irregular rows of tactile setæ, not arranged in groups, but springing in an almost continuous series. The two rows differ in size; those of the proximal or dorsal row are short, like those of the groups; those of the distal or more ventral row are long and stout. The same arrangement is repeated on the endopodites and exopodites of the 6th pair of swimmerets. The fringing setæ pass up for some distance along the margins of all the elements of the fan; the tactile setæ are altogether confined to the free edge of the fan; and on the exopodite they are not found beyond the point where, in the ordinary state of extension, it is overlapped by the endopodite; while on the telson these characteristic marginal tactile setæ cease from the point where it overlaps the endopodite. Thus there is a complete fringe of tactile setæ along the free margin of the caudal fan. On the under surface of the caudal fan there are a few small groups.

Experimental.—The pleura are sensitive at the extremities, and the tufts there are brought close together when the abdomen is flexed (its usual position); there is thus no overlapping. Lemoine (*loc. cit.*) says that "les palettes de la queue" are especially sensitive, and remarks that they have a fringe of hairs which are very susceptible to tactile impressions. This observation I have frequently confirmed, and the presence of the numerous tactile setæ fully explains it. I may add, to show the extreme sensitiveness of this part, that if, when the animal is lying quietly on its back, any part of the edge of the fan be simply pressed with the

fingers, the creature instantly flexes its whole body on the abdomen, and the greatest quickness is necessary in removing one's fingers out of the reach of its claws. The invariable position of the tactile setæ of the abdominal somites *outside* the fringing hairs is worthy of remark. While the appendages of the head and thorax form a sort of tactile zone round those parts of the body, the abdomen, though less well provided with tactile limbs, has also a tactile zone of a more simple kind.

Swimmerets.—On the coxopodite, which is very small, there are no tactile setæ; on the basipodite there are a few small irregular groups; but on the endopodite and exopodite, on which the arrangement is practically identical, both the tactile and fringing setæ are very numerous, and it is here that their relation to other parts may most readily be made out. The fringing setæ are arranged in a single row along the margin and across the apex, standing on their characteristic pedestals. They have their flat surface in the same plane as the flat surface of the swimmeret, and increase its surface. Here the tactile setæ are most numerous and longest at the apex, and are present in about equal numbers on both the anterior and posterior surfaces of the appendages. They stand singly, as the cuticle is thin, and pass back a short distance up the joint, the proximal ones being much



Stanford University Libraries

In *Thysanopoda*, a free-swimming form, there is obviously little need of a complete sensitive investment, and here we find the tactile setæ concentrated in the fore-part of the animal, and only present on the tips of the thoracic appendages, on the gnathites, and on the two pairs of antennæ, which are richly furnished with them; and which, as they are very long and mobile, compensate the animal (in the same way as in the carapace of *Astacus*) for the want of tactile setæ on the posterior somites.

In the creeping forms, on the other hand, such as *Homarus* and *Astacus*, the necessity for being able to receive tactile impressions from without is evidently much greater, when at any moment danger may threaten these animals from among the rocks and stones where they live; and where, as in *Homarus*, the integument is so thick and strong that the animal may practically disregard most enemies, the tactile setæ are found thickly set at a few points only; while in *Astacus* the relative thinness of the integument has brought about a much wider distribution of tactile setæ.

Nervous Apparatus.

I have studied the nerve-endings, more especially in the "hand" of the great claw, as in that portion of the propodite or 6th joint, which is prolonged to oppose the dactylopodite, there is a mass of connective tissue, which can be drawn out from the hard cuticle and subjected to various methods. That which I found most useful was preliminary treatment with a saturated solution of corrosive sublimate, staining *in toto* with various dyes, and then embedding in paraffin, by which means I was enabled to obtain several complete series of sections in various directions. I have also studied fresh sections, and have treated the tissue with osmic acid, chloride of gold, and other re-agents.

The nerve of the limb divides in the swollen part of the propodite into too large branches, one of which goes to the dactylopodite, the other to the "anvil" of the propodite. These nerves run at the sides of the limb (their course is shown somewhat diagrammatically in Pl. IX., Fig. 17), giving off branches to the flexor and extensor muscles of the dacty-

lopodite. At the point where the nerve to the "anvil" leaves the portion taken up by muscle and enters the mass of connective tissue, there is a small ganglion upon it, consisting of three or four cells of the ordinary type, surrounded by a connective tissue envelope, and disposed irregularly in the course of the nerve. I shall have more to say of the function of this later on.

The nerve-endings are surrounded by blood-sinuses, and are slung in these by trabeculæ of connective tissue, and the surface of the nerves and nerve-endings is covered with a continuous endothelium, which may be demonstrated by injection from the heart with nitrate of silver solution, when the characteristic pattern becomes evident. The nerve-fibres are directly continuous with the tactile end-organs, which lie usually at an acute angle with the surface of the hypodermis, in continuation of the direction of the nerves themselves (*see* Pl. VIII., Fig. 3). They vary considerably in length, from 0·1 mm. to 0·2 mm., and exceed the nerve-fibres slightly in breadth, but not very greatly; that is, they are from ·015 mm. to ·030 mm. The largest are those nearest the tip of the claw where the setæ in the tactile tufts are most numerous. They are approximately cylindrical; are surrounded by a homogeneous, highly-refracting membrane, continuous with the trabeculæ of the connective tissue which sling the

Stanford University Libraries

The nuclei themselves are large, ovoid, granular, and contain one or more nucleoli, which refract light very strongly, and usually lie at the periphery of the nucleus (it is possible that they do so always, and that their occasional apparently central position is merely due to the fact of their being seen on the top of or through the nucleus). At the proximal end of the tactile organ, the nerve-fibrils break up and become continuous with the protoplasm in the way that has been so frequently described and figured in connection with ganglion-cells, and at the distal end the process is reversed, and the nerve-fibre is re-formed, and is of about the same size, and has the same structure as when it entered the end-organ. It then bends round and passes through the hypodermis in a direction approximately at a right angle to its surface; in the last part of its course it comes into contact with an in-growth of the hypodermis cells, which is probably the "hair-tube" of Hensen and Braun.

From a careful comparison of the position of the tufts of setæ on the outside of the claw and the nerve-endings within, and from an examination of decalcified preparations, I have come to the conclusion that there are generally three or four nerve-end organs to each of the larger tufts of setæ; at any rate, if the tuft does not consist of more than half a dozen setæ or so, one end-organ seems to suffice. The way in which the nerve is connected with the setæ is the same in both cases. This concentration is curious, and seems to run parallel with the collection of the setæ into tufts. Each nerve-fibre, after leaving the end-organ, and passing after a shorter or longer course through the hypodermis, divides into several branches, one for each seta which it supplies, and these enter the canals which traverse the integument, and whose presence has been demonstrated by Vitzow and others, and which I shall for convenience call "nerve-canals." The hypodermis does not enter these canals, which are only large enough to admit the nerve-fibre. The nerve-filaments run on to the slight dilatation of the canal which underlies the "areola" of the seta; here they seem to swell slightly, and then they enter the lumen of the seta, which is in direct communication with the lumen of the canal. The nerve-

fibril does not pass up the whole length of the interior of the seta; moreover, from the manner of formation of the seta, it would be difficult to conceive of a continuation of the fibril up the lumen. The granular appearance which Leydig first remarked in the interior of similar setæ, and considered to be due to a "nervous substance," is due (when it is present) to the products of the breaking down of Braun's "hair-papilla."

There is not, however, such a definite and easily visible point of attachment as that which Hensen describes in the auditory setæ, and calls the "lingula" (*see* his figures 17, 20, 30, etc.); the manner of attachment is shown in Fig. 12. The nerve is attached or opposed to an oval surface (Hensen describes his "lingula" also as an "extended oval") a very short distance from the base of the seta, but distinctly in the lumen. The lingula projects slightly into the lumen, and if setæ be broken off under the microscope near the base, and a staining agent, such as saffranin, be then applied, it is stained deeply. Of the nature of the mode of attachment, further than that the end of the nerve-fibre lies against this spot, and is evidently intimately connected with it, I can give no account. This nervous connection is evidently homologous with Hensen's "chorda," but differs from it in not being chitinous; and I can only understand what he

Stanford University Libraries

would have found that they invariably possess a lumen. Their appearance so closely corresponds with Braun's own figure (*loc. cit.*, Taf VIII., Fig. 5) of a salivary gland from the æsophagus, that I refrain from drawing them.

There are usually two lobes, sometimes, however, four or more, and the lumina of the ductules converge to a point, usually about the middle of the body, where they fall into a common duct, which, piercing the superjacent connective tissue and integument, opens on the external surface of the claw. At the point where the main duct arises there are generally two or three large nuclei different in appearance to those of the proper cells, but of whose nature I am not certain. They probably have formed the duct, and now remain as part of its wall. The form of these proper cells is as Braun describes it, and the part nearest the lumen is usually full of strongly refracting granules. From the above facts, and since, moreover, these bodies are surrounded by blood-sinuses—as indeed all actively functional parts in the crayfish are—I consider myself entitled to regard them as glandular, though what is the nature of their secretion or excretion I cannot venture even to conjecture.

It may be noticed here that Claus[1] describes, in the thoracic appendages of *Phronima*, glands opening to the exterior, and precisely similar to the salivary glands, which he also figures. Though these are much simpler than the glands in *Astacus*, they are yet very like them; they have the same kind of duct and the same nuclei at the root of the duct. The main difference is that in *Phronima* the ductules are intra-cellular, in *Astacus* inter-cellular. Claus suggests that these glands in the legs secrete saliva, or something like it, which is mixed with the food before actual ingestion; but I think that this must at present be left undecided.

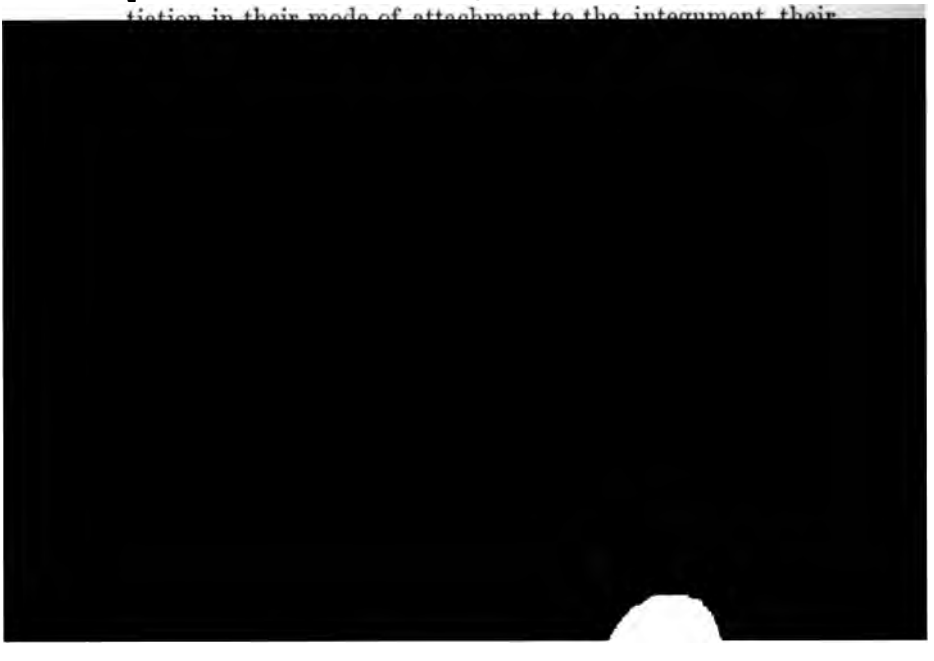
Ganglion of the Great Claw.—With regard to the ganglion on the nerve running to the claw, I was for some time of the opinion that it might possibly be a reflex centre for the closing of the pincers, and that nerve-fibres might pass from it to the great flexor or adductor muscle of the dactylo-

[1] Der Organismus der Phronimiden, Arbeiten a. d. Zool. Inst. Wien II., 1879, pp. 17-23, figs. 11, 16, etc.

podite; but a few experiments convinced me that the centre for this action was in the central nervous system, and probably in the ganglion of the cord corresponding to the great claw. I found that if I divided the nerve in the appendage, or destroyed the ganglion corresponding to the claw through the sternal wall, while the peripheral ganglion remained intact, no amount of stimulation of the tufts of setæ would bring about closing of the pincers. One is therefore, I think, entitled to regard this ganglion as sensory in function, which opinion also its position confirms, since it lies on the nerve at a point proximal to the junction with it of all the sensory nerves returning from the tufts of setæ in the "index" of the propodite. It therefore probably collects the impressions from the ultimate nerve-end organs, and transmits them to the central nervous system.

The Genealogy of the Setæ.

It is, perhaps, rather premature to attempt to trace the genealogical relationship of the setæ, but I shall make an attempt to do so from data furnished by my own researches and those of others. I regard a form nearly allied in structure to the fringing setæ as most primitive, since these present less evidence than any other of the setæ of differen-



Stanford University Libraries

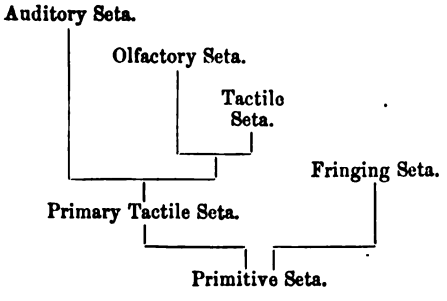
fringing seta was developed by the loss of the nerve-filament in situations where increase of surface, straining, or other mechanical function was necessary, by the seta becoming flatter and longer, by a slight complication of the articulation, and, at a comparatively late stage and in consequence of the loss of the nerve, by the closure of the lumen.

From the primitive form, in another direction, were developed the various sensory setæ; all the setæ which remained sensory were probably primarily tactile, since the sense of touch is undoubtedly the most ancient and most widely diffused of the senses, and from this form the secondary tactile, auditory, and olfactory setæ were evolved. The auditory setæ retained the side bristles,[1] probably because these were useful in collecting minute vibrations in the surrounding fluid, but developed a complicated mode of articulation (Hensen, *loc. cit.*), and were (in *Astacus*) confined to a closed sac on the antennules, where their extremities were imbedded in the otoliths.

In another direction diverged a form from which the olfactory and tactile setæ were developed by another process of separation. The characteristics of this intermediate form were the mode of articulation, which differed only in the amount of movement allowed from that of the fringing seta—and was thus much simpler than that of the auditory seta—and the entire, or almost entire, loss of the secondary bristles. From this, again, the olfactory setæ were developed in one special and sheltered position, the antennule. They retained the flat shape, and in most forms have entirely lost the secondary bristles, but in *Thysanopoda* (Pl. VIII., Fig. 6, *a*, *b*) a few of these have been retained on one side, to testify to the origin of the setæ. On the other hand, the tactile setæ were developed wherever the animal would have to come in contact with rougher impressions, and therefore appeared mainly at the *extremities* of the appendages, so as to give the animal as long a warning as possible of the nearness of danger or difficulty. These setæ have completely lost the secondary bristles, though a reversion to the ancestral type, or survival of it, is to be seen in the occasional slight serration of the distal portion in both *Astacus* and *Thysanopoda*.

[1] *Cf.* Huxley, Crayfish, p. 117; and Hensen, *loc. cit.*, p. 348, and Fig. 38.

They have, moreover, had to become as strong as possible, in order to resist the rough usage to which they are necessarily exposed, and have therefore become cylindrical, and have greatly thickened their walls at the expense of the lumen. They have also greatly adapted themselves to the circumstances of their position in regard to length, stoutness, and amount of aggregation; the details of this adaptation have been given elsewhere. I need scarcely say that the intermediate forms above described are not to be found in the adult *Astacus;* it would be interesting to seek them in young stages. I append a tree presenting in tabular form the result of the reflections given above:



With regard to this loss of secondary bristles in the tactile setæ, it is interesting to compare the figures of Grobben,

Stanford University Libraries

dipterous larva among simple setæ one feathered along one side, and this must be developed at the completion of the metamorphosis into the strong setæ closely resembling the tactile setæ of *Astacus*, which Leydig[1] has figured in *Musca vomitoria*. The undoubtedly tactile seta which Claus figures in *Sida* (*see* Pl. VIII., Fig. 9) shows a slight feathering or serration, which in this low crustacean is probably only in process of disappearance.

Explanation of Plates.

Plate VIII.

Fig. 1. Tactile seta from great claw, seen from above.

Fig. 2. Stunted fringing seta from great claw.

Fig. 3. Nerve-ending from claw of *Astacus*. *b.c.*, blood-corpuscle; *g.n.*, nucleus of ganglion-cell; *ner. n.*, nucleus of nerve-fibre; *c.t.*, conn. tiss. trabeculæ; *c.t.c.*, conn. tiss. corpuscle; *end. n.*, nucleus of endothelium.

Fig. 4. Tuft of tactile setæ from great claw.

Fig. 5. Nerve (from claw) dividing to enter three nerve-endings. *hy.*, hypodermis cells; *N.*, nerve; *g.n.* and *ner. n.* (*see* Fig. 3).

Fig. 6. Olfactory setæ from antennule of *Thysanopoda*, showing feathering on one side; *O.*, olfactory seta; *T.*, tactile seta; *a.*, from the side; *b.*, olfactory seta from the front.

Fig. 7. Peculiar fringing seta from maxillipede of *Astacus*.

Fig. 8. Tactile seta of *Branchipus* (after Leydig) to show the nerve-ending. *Gz.*, ganglion-cell; *Maz.*, matrix (hypodermis) cells; *T.*, tactile seta.

Fig. 9. Tactile seta of *Sida* (after Claus). *Gz.*, *Maz.* (as above); *Af.*, "axial thread" (Achsenfaden); *Ma.*, "extension of the matrix into the seta;" *N.*, nerve.

Fig. 10. Tactile seta of *Ptychoptera* (after Grobben).

Plate IX.

Fig. 11. Tactile setæ of *Corethra* (after Weismann), to show the gradation from the feathered to the unfeathered form.

Fig. 12. Small tactile setæ of *Astacus*. *a.*, from a swimmeret; *hy.*, hypodermis cells; *N.*, nerve; *b.*, from the palp of the mandible, showing serration.

Fig. 13. Fringing seta from the side of a swimmeret, too long to be figured entire. *int.*, integument; *cl. p.*, closing plate (seen from the anterior surface).

Fig. 14. The two distal joints of a thoracic appendage of *Thysanopoda*. *T.*, tactile seta; *F.*, fringing seta.

Fig. 15. Tactile seta from thoracic appendage of *Thysanopoda* to show slight feathering.

Fig. 16. Fringing seta of *Thysanopoda*, too long to draw in its entirety.

Fig. 17. Diagram of the course of the nerve (*N.*) in the paspodite and dactylopodite of 4th thoracic appendage of *Astacus*, and of the position of the tactile tufts (*T.t.*). *G.*, ganglion. The muscles are coloured pink.

Fig. 18. Short and stout tactile seta from 1st maxilla of *Astacus*.

[1] Zur Anatomie der Insecten, Taf IV., Fig. 36.

as does a third radial (R. 3). There are thus two third brachial plates supported by the triangular second brachial, and each of these two third brachials is, of course, the starting-point for a long series, and thus the division of the arm is brought about. It is interesting to note the behaviour of the syzygies under these circumstances. Normally a syzygy occurs between the third and fourth brachial plates, or, perhaps, more correctly speaking, in the middle of the third brachial; in this divided arm each of the two third brachials has a syzygy (Fig. 2 *Sg.*). The second brachial plate supporting the two halves of the divided arm bears no pinnule, as it normally does, but in each of the two halves of the divided arm the first pinnule is given off on the outside, immediately above the syzygy (*vide* Fig. 2).

The fourth and fifth arms of the right hand side arise in a perfectly normal manner. On the left hand side the first, second, and third arms arise as usual; the fourth, however, behaves just like the third arm of the right side—that is to say, the second brachial acts like a third radial, and bears two third brachials. The only difference concerns the syzygies, and consists in the development of an extra syzygy in the anterior half of the divided arm (Fig. 2, L. 4 *a*), in the position shown in the figure (*Sg.*).[1] The fifth arm of the left hand side arises as usual.

Stanford University Libraries

XII. *Notes on the Occurrence of the Shorelark* (Otocorys alpestris) *in East Lothian.* By Mr GEORGE POW. [Communicated by WILLIAM EVANS, Esq., F.R.S.E.] (Specimen exhibited.)

(Read 17th February 1886.)

On 30th January 1886 a flock of six shorelarks was observed by my friend, Mr R. R. Sutter, East Barns, to rise from a field of barley stubble near Thorntonloch, about five miles to the eastward of Dunbar. The field lies adjacent to the sea, and the birds had settled in a slight hollow about a hundred yards from the beach. They were in company with about a score of skylarks, and on the flock being disturbed, the species separated. Mr Sutter distinguished the shorelarks from the skylarks by their heavier flight, and, following them up, was successful in securing two specimens, both of which, I am informed by Mr Evans, who dissected them, were males. One of them, through the kindness of Mr Sutter, is now before the Society. The other is very similar to it in plumage.

A week later, in company with Mr Evans, I went over the ground where these specimens were got, but, in spite of a diligent search, none of the remaining birds could be discovered among the numerous skylarks, etc., which we raised. That they were still in the neighbourhood was, however, beyond doubt, for on returning to the field after about an hour's absence, we came upon the remains of one newly killed—presumably by a hawk that we had observed hunting in the vicinity. In addition to the usual mass of feathers, the remains consisted of the sternum and other bones—all most perfectly divested of the flesh, but with the wings and legs still attached—and the stomach. The head appeared to have been entirely swallowed. Mr Evans informs me that the stomachs contained the seeds of an Atriplex, a Polygonum and a small leguminous plant, together with a few of the cotyledons or first leaves of some plant, all mixed with a copious supply of grains of quartz. From the throat of one of the birds I took two grains of barley.

The first recorded Scotch killed shorelark was a male,

shot by Mr Evans' father near the mouth of the Tyne, East Lothian, on or about 10th January 1859, and exhibited at a meeting of the Royal Physical Society on the 27th of April following. This specimen, which is preserved under the foot of a shrike, still forms part of the collection of the late Dr C. Nelson of Pitcox, near Dunbar, to whom it was presented. Since then the species has been captured on two other occasions in the Tyne estuary—namely, during the winters of 1869-70 and 1879-80, and twice at the mouth of the Eden, near St Andrews—namely, in the winters of 1865-66 and 1869-70. Mr M'Leod, of Belhaven, Dunbar, informs me that he saw several in company with skylarks also on Tyne sands in the winter of 1877-78. The species does not appear to have ever been observed in any other parts of Scotland.

XIII. *On the Occurrence of the Great Snipe* (Scolopax major) *near Glasgow in May* 1885. By WILLIAM EVANS, Esq., F.R.S.E. (Specimen exhibited.)

(Read 17th March 1886.)

On 16th May last (1885) a pair of great snipes, male and female, were shot on rough pasture at Clydebank, on the north side of the river, about four miles below Glasgow.

Stanford University Libraries

the occurrences are so few and uncertain that, for the present at any rate, we would scarcely be justified in classing it as other than an irregular visitor on spring and autumn migration, though it is highly probable that the bird is not unfrequently shot by sportsmen who do not discriminate between it and the common species—its larger size exciting little or no surprise in view of the great variation known to exist in this respect among individuals of our native snipe.

An examination of the records of the occurrence of the great snipe in our islands shows that it has been observed far oftener in autumn than in spring; and, indeed, the chief interest attaching to the two specimens which form the subject of this note, is that they are believed to be the first which have been obtained in Scotland in the latter season of the year. The fact that they were a pair, male and female, and that they occurred at a time when all our native birds were in the midst of the duties of incubation, might not unnaturally lead to the supposition that they would have nested with us had they been allowed to remain unmolested, but when we bear in mind that it is one of the last birds to arrive on its breeding grounds in the north of Europe—only passing Gibraltar in the latter part of April, and not reaching Scandinavia before the middle or end of May, or even till the first week of June in the Arctic Circle—there can be little doubt that they were merely resting on their northern journey.

Reports of the occurrence of the great snipe in Scotland, which now and again reach our ears, cannot, in the absence of the usual evidence, be as a rule founded upon; and I think I am within the mark in saying that there are not more than seven or eight authentic specimens hitherto on record. Among them is one which was obtained at Torhousemuir, Wigtownshire, on the 5th of September 1874, and exhibited at a meeting of this Society by the late Dr J. A. Smith on 17th November following. The species appears to have occurred rather oftener on the east than on the west side of the country, but I am not aware of any record of its occurrence in the Lothians, though it has been obtained two or three times in Fifeshire, once in Roxburghshire,[1] and once in Ber-

[1] On 15th September 1886 I saw a fine specimen (a male) in the hands of

wickshire, in which county the Earl of Haddington states one was shot by his father at Mellerstain in the autumn of 1865, and another seen by himself about the same time near Earlston, as recorded in Gray's "Birds of the West of Scotland."

XIV. *Notes on the Occurrence of the Stock Dove and White Wagtail in East Lothian.* By WILLIAM EVANS, Esq.

[ABSTRACT.]

STOCK DOVE (*Columba œnas*).—At the monthly meeting of the Society held on 17th March 1886, Mr Evans exhibited a specimen of the stock dove, obtained near Longniddry on the 6th of January 1886. When shot it was feeding in a wood, in company with a number of ring doves, on Indian corn, which had been placed there for the pheasants. On dissection it proved to be a male. The Society's *Proceedings* contain several valuable communications on the appearance and spread of the species in Scotland, and the interest attaching to the present specimen lies in the fact of its being the first recorded from East Lothian, or, indeed, from any of the three Lothians.[1] A second specimen—a male—was subsequently netted, along with a number of ring doves, in the same locality on 5th March 1886.

Stanford University Libraries

XV. *On the Relation of Yolk to Blastoderm in Teleostean Fish Ova.* By GEORGE BROOK, Esq., F.L.S., etc., Lecturer on Comparative Embryology in the University of Edinburgh.

(Read 20th January 1886.)

In January 1885 I contributed a paper to the *Quarterly Journal of Microscopical Science*, in which the view was advocated that the hypoblast in pelagic fish ova was not derived from an invagination of the archiblast, as has usually been supposed, but was formed almost entirely from the parablast. This view has been received with a good deal of scepticism, and indeed it is entirely at variance with the generally accepted theory of Teleostean development. Nevertheless I was from the first thoroughly convinced of the accuracy of my statements so far as the material at my disposal was concerned. Having during the past twelve months had increased opportunities of studying the early stages of development of several fishes, I have taken up the subject *de novo*. The results of my inquiry lead me to reaffirm with greater emphasis my former position. Hoffmann, Agassiz, Whitman, and others, have during the past few years made a study of the development of pelagic Teleostean ova. With similar material to work upon, and in spite of the greater accuracy of embryological methods, it is a remarkable fact that no two authors are agreed on a single important point. It is very improbable that there is such a great variation in the early stages of Teleostean development as the various authors have described. I do not propose for the present to enter into any detailed discussion of the origin of the parablast. The object of the present paper is to take up the question from an entirely different point of view. I hope to show that a careful study of the nature and behaviour of the yolk in meroblastic ova, and a comparison with what obtains in holoblastic types, will of itself throw very important light on the much-vexed parablast question. For this purpose it will be necessary to glance at the structure and growth of the ovarian ovum.

The primitive ova, when they leave the germinal epithelium, are small simple cells, containing a large nucleus, within which is a dense nucleolus which stains deeply. The cell protoplasm is slightly granular, but has at this time no special supply of food material. Later a follicle is formed, enveloping each egg, which is also derived from the germinal epithelium. The egg then gradually increases in size, the follicle forming the medium through which nourishment is received. It is important to note that from this time onwards the egg contains a new element. The cell protoplasm increases steadily in bulk, but at the same time the excess of nutritive material becomes specially collected in the form of food yolk, which is intended for the nourishment of the future embryo. This food yolk is not distributed throughout the cell protoplasm, but forms separate masses, which contain little or no protoplasm. The relative distribution of protoplasm and yolk in a fish ovum as it approaches maturity varies considerably. In the pelagic group of ova the germinal protoplasm usually forms a comparatively even superficial layer around the single large yolk sphere. In the herring and some other fishes the yolk consists of a large number of slightly refractive spherules, and the germinal protoplasm is distributed as a network between the yolk spheres. In the Salmonidæ a relation exists which is somewhat intermediate

Stanford University Libraries

equally well for the Gadidæ, and indeed for all pelagic fish ova which I have examined. In the herring and like forms a similar arrangement is found, only that the communication between protoplasm and yolk is never so completely lost as in the pelagic ova. In the Salmonidæ, both before segmentation commences and throughout this process, a comparatively thick cortical layer of protoplasm is found, which is intimately connected with the yolk. Here the cortical protoplasm has an additional function. The yolk substance coagulates instantly when brought in contact with water. The cortical protoplasm acts as a protective membrane and prevents this coagulation. Oellacher drew attention to this point fourteen years ago, and also showed that this cortical layer must be regarded as a part of the germinal protoplasm of the ovum.

Let us now reflect on the structure of a Teleostean ovum immediately prior to the commencement of the segmentation process. Oellacher, in the paper referred to, uses what appears to me a very good simile. He compares the meroblastic ovum of the trout to a gigantic fat-cell, the extension of the cortical protoplasm around the yolk being regarded as equivalent to the thin extension of the cell-protoplasm around the fatty substance of the latter. There is another point of similarity which is important. The fat contained within the protoplasm of the fat-cell is a store of passive food material, which can be drawn on as occasion requires. Precisely the same relation exists between germinal protoplasm and food-yolk in the fish ovum, and doubtless also in all meroblastic ova. The distinguishing feature of a meroblastic ovum is that its constituent parts are practically separated into two distinct areas—protoplasm and yolk. The yolk is included within the cell substance, but does not form an essential part of it, so far as its characters as a cell are concerned. In the meroblastic ova of many invertebrates —for instance, in *Peneus*—the yolk takes a more or less central position, while in the fish ovum the yolk, although situated eccentrically, is still completely surrounded by the cell-protoplasm. The difference between *centrolecithal* and *telolecithal* ova thus becomes more one of degree than of kind.

Turning now to the consideration of holoblastic ova, let us glance at the structure of the ovum of the Mollusca and the Amphibia. In the unsegmented egg there is no separation of protoplasm from the yolk. Even after the formation of the first equatorial furrow, when the ovum is divided into an animal and a vegetative pole, it can only safely be stated that the animal pole is richer in protoplasm, while the vegetative is richer in food-yolk. The food-yolk being distributed throughout the protoplasm with each succeeding division of the egg, cells are produced, which consist partly of protoplasm and partly of yolk. Each cell, in fact, carries its food supply along with it. There is thus no special store of nutriment in a holoblastic ovum such as is found in a meroblastic one. A meroblastic ovum is generally regarded as an ovum which is only prevented from segmenting as a whole by the presence of a preponderating amount of food-yolk. This undoubtedly expresses a part of the difference between, say, a Teleostean and an amphibian ovum, but not, as I take it, the characteristic difference. I can conceive of an ovum containing precisely the same *proportion* of food-yolk to protoplasm as is found, say, in the egg of the frog, but which would not be holoblastic in its segmentation. If, for instance, the whole of the yolk material in the frog ovum were concentrated into a solid yolk mass instead of being distributed throughout

Stanford University Libraries

vegetative area, morphologists have sought to explain the partial segmentation of meroblastic ova as an extension of the same retarding process. It is usually stated that in a meroblastic ovum, such as that of the cod, the first furrow *theoretically* divides the ovum into two equal parts, but that *practically* this furrow is incomplete on account of the overwhelming preponderance of food material in the lower pole. To my mind such a statement is misleading; it presupposes an analogy which does not exist. It is the *difference in the distribution of the yolk* in the two cases which destroys the analogy. If the yolk-pole of the cod ovum only differed from that of an amphibian in containing an enormously greater proportion of yolk, the analogy might hold good. The difference, however, is far greater. The yolk-pole consists of one large sphere of passive food material practically void of protoplasm, around which there is a thin layer of protoplasm, which is part of the germinal area. The outlines of the two, however, are well defined.

To return to the analogy of the fat-cell. If a cell, containing within its protoplasm a large fat vesicle, were to divide and give rise to two daughter cells, no one would suppose for a moment that the line of cleavage passed *theoretically* through the centre of the fat vesicle. I submit that the case of the cod ovum is precisely analogous. I am aware that in some fish ova the separation of protoplasm from yolk is not so complete as is the case in the pelagic group of ova. The protoplasm and the yolk are, however, distinct from each other, and it is only because certain protoplasmic processes are pushed in amongst the yolk spheres that the active and passive portions of the egg are brought into closer union. It appears to me, therefore, that there is no benefit to be derived by theoretically regarding any furrow as passing through a mass of passive food material, which is of no use to the embryo until it has become converted into active living protoplasm. This brings us to the question, How does the food-yolk become utilised in the fish ovum? My answer is, through the agency of the *parablast*, and probably through that agency alone. I have previously defined the parablast as primarily consisting of that portion of the germinal pro-

toplasm which is not included in the germinal disc. To take, again, the example of *Trachinus*, the collection of protoplasm at the upper pole (the lower as the egg floats) of the egg may be conveniently termed the *germinal mound* or *germinal area*, as the whole of this protoplasm is not included in the germinal disc, that is to say, in the archiblast. When this becomes defined, there is still left a thin layer of the original germinal protoplasm around the yolk, which is the parablast. If the whole of the germinal protoplasm were included in the archiblast, it is clear that any absorption of nutriment which could take place through the cell-wall would be much too slow a process for the nourishment of a rapidly-increasing organism. So long as there is a layer of naked protoplasm around the yolk, intracellular digestion may take place. As a matter of fact, the cortical protoplasm does include particles of yolk material within its substance, and digests them there. In this manner the food material is assimilated. It thus becomes the special function of the parablast to act as an intermediate digestive area between the segmenting archiblast and the passive food-yolk. The importance of this layer has already been recognised by Waldeyer and others in the development of the chick and other forms. It is only amongst the students of Fish Em-

Stanford University Libraries

the formation of the embryo, and practically that the nuclei of the parablast layer are morphologically functionless. He regards the nuclear material of the parablast as analogous to that in the yolk-pole of a holoblastic ovum, which, under its new conditions, may go on dividing, but which has no longer any part to play. Others, headed by Gensch, have shown, I think without doubt, that the parablast cells play a prominent part in the formation of blood and the connective tissue series, and in fishes the perivitelline circulation is probably of parablastic origin. In the herring, cod, *Trachinus*, and probably the whole group of pelagic ova, there is, however, no trace of a vitelline circulation, yet cells are produced in the parablast of these forms in the same manner as in the trout. Further, these cells appear quite as early in the herring and similar forms—indeed, apparently earlier in some cases. What, then, can become of these early differentiated cells? In the cases cited there is no vascular system until a late stage, so they cannot be transformed into blood corpuscles, yet they most certainly do not undergo degeneration. There thus appears no alternative but that the cells must take part in the formation of the embryo itself. It thus appears that, from a consideration of the physiological function of the parablast, the morphological value of this layer is seen to be more important than has hitherto been admitted. I have purposely omitted here any reference to Ryder's theory of "Yelk-hypoblast," because this has reference only to the absorption of that portion of the food-yolk which remains unassimilated at the time the embryo hatches.

XVI. *Notes on Birds observed on various Voyages between England and the Cape of Good Hope.* By Spearman Swinburne, Esq. (Communicated by J. J. Dalgleish, Esq.)

(Read 17th February 1886.)

The following is a short account of the different birds seen on a series of voyages from Southampton to Cape Town, extending over a period of two and a half years, from July

1884 to January 1886.[1] It would at first appear, from the number of species given, that birds are plentiful at sea. This, however, is by no means the case, as particularly in the Tropics, we frequently pass days without seeing a bird, and those that are seen at other times are often single specimens, made out with the aid of a good glass. After leaving England we generally see a few British birds as far as Madeira. As we go south from that island, birds become scarce, and after we pass the Bijouga islands, in Lat. 11° N., they disappear almost entirely, to reappear again in about Lat. 15° S. From there to the Cape they are more common, and round the Cape coast are generally plentiful—numbers of the Cape gannet, yellow-nosed albatross, and black petrel being generally seen round the ship. Of the different species given in the list, few have been actually caught or shot by me, as shooting from a steamer is of course not generally permitted, and if so it would be useless to the collector, as he would be unable to pick up the birds when shot. Again, in port we are generally busy, and have no time for collecting specimens.

1. *Falco subbuteo*, Linn.—Hobby.—Two seen, one in Lat. 42° N., Long. 11° W., and one in Lat. 26° N., Long. 17° W., which latter alighted in the rigging.

2. *Strix flammea*, Linn.—Barn Owl.—One seen on 23d October 1885 in Lat. 35° N., Long. 15° W., which flew round

Stanford University Libraries

round the ship on 16th March 1885, in Lat. 36° N., Long. 14° W.

7. *Linota cannabina* (Linn.)—Linnet.—One seen 29th August 1885 in Lat. 46° N., Long. 8° W.

8. *Emberiza citrinella*, Linn.—Yellow Bunting.—One flew on board on 25th April 1884 in Lat. 16° N., Long. 17° 30′ W.

9. *Nectarinea*, sp. ?—Sunbird, apparently a female, with dull brownish plumage and light breast, seen on 19th October 1885 in Lat. 17° N., Long. 17° 30′ W.

10. *Garrulus*, sp. ?—A jay, probably *Cervicalis*, Bp., the Algerian species, observed on 6th August 1886 in Lat. 16° 30′ N., Long. 17° 48′ W.

11. *Hirundo rustica*, Linn.—Swallow.—Not uncommon in spring and autumn, but never seen in large numbers, generally only two or three together. I have observed them chiefly between Madeira and Cape Verde.

12. *Chelidon urbica* (Linn.)—House Martin.—Fairly common in March, April, May, and October. They are generally seen in the same latitudes as the swallows, and often in company with them.

13. *Cypselus apus* (Linn.)—Swift.—One seen on 6th August 1886 in Lat. 16° 30′ N., Long. 17° 48′ W.

14. *Turtur communis*, Selby—Turtle Dove.—One alighted on board, apparently exhausted, on 29th August 1885 in Lat. 46° N., Long. 8° W. Another seen 20th September 1886 in Lat. 17° 18′ N., Long. 17° 49′ W.

15. *Columba*, sp. ?—A pigeon, resembling the rock dove, flew about the ship on 16th November 1885 in Lat. 13° N., Long. 18° W., but did not alight.

16. *Upupa epops*, Linn.—Hoopoe.—I have observed this bird come on board several times in different latitudes. It generally alights, but is very shy, and will not allow itself to be caught. The following are the dates and positions of four specimens observed: (1.) 29th December 1884 in Lat. 7° N., Long. 15° W. (2.) 14th March 1885, Lat. 46° N., Long. 8° W. (3.) 18th March 1885, Lat. 27° N., Long. 17° W. (4.) 5th August 1886, Lat. 21° 49′ N., Long. 17° 36′ W.

17. *Vanellus cristatus*, Mey.—Lapwing.—Saw two on March 14, 1885, in Lat. 46° N., Long. 8° W., flying north.

18. *Strepsilas interpres* (Linn.)—Turnstone.—I observed one specimen of this cosmopolitan species flying round the ship in Lat. 12° N., Long. 17° 30′ W.

19. *Numenius arquata* (Linn.)—Curlew.—Not uncommon at sea between Cape Verde and the Bijouga Islands, where they often keep wheeling round the ship, never coming very close, and always keeping out of gunshot. I have observed them in August, October, and November.

20. *Totanus hypoleucus* (Linn.)—Sandpiper.—Seen occasionally in the Channel, and also about the same locality as the last species. They are generally seen singly, and never alight on board.

21. *Gallinago cœlestis* (Frenzel)—Snipe.—One seen flying on 21st November 1884 in Lat. 35° N., Long. 15° W. It did not alight.

22. *Phalaropus fulicarius*, Linn.—Grey Phalarope.—This species is pretty common off the north-west coast of Africa between January and March. I have frequently seen them flying north in small flocks, and sometimes swimming. They were probably on migration. I have never seen any going south in the autumn.

23. *Fratercula arctica* (Linn.)—Puffin.—Some seen in the Channel.

24. *Sphenisc[illegible]* (Linn.)—Jackass Penguin.—Very

Stanford University Libraries

Lat. 9° S., where they get scarce. About Lat. 20° S. we meet them again, and they get more common as we near the Cape. Round the South African coast they are sometimes seen in flocks, but they do not come near shore. Farther south, in Lat. 40° to 45° S., they are very common, and follow ships in great numbers along with the albatross and Cape pigeon. On one occasion, near the Bijouga Islands, we saw dense clouds of these birds, so much so that we at first took them for land.

27. *Puffinus griseus* (Gm.)—Sooty Shearwater.—Sometimes seen in the South Atlantic, but not at all common.

28. *Puffinus anglorum* (Temm.)—Manx Shearwater.—Not very common. I have seen one or two between Plymouth and Madeira, and one once off Teneriffe.

29. *Puffinus obscurus*, Bonap.—Dusky Petrel.—Two apparently of this species were observed in Lat. 17° S., Long. 13° W.

30. *Procellaria pelagica*, Linn.—Stormy Petrel.—Common in north latitudes, where a few are generally to be seen in the wake of the ship. It is not so common in more southerly waters.

31. *Oceanites oceanica* (Kuhl.)—Wilson's Petrel.—Common in the Tropics and south as far as the Cape. It is often seen in company with the last species, from which it is readily distinguished by its size and white wing markings.

32. *Oceanites leucogaster* (Gould)—White-bellied Petrel.—A species chiefly seen near Cape Verde, where it is not common. It flies with an unsteady, wavering flight close to the water, and is sometimes seen to glide along for some distance with its wings perfectly still and legs hanging down, frequently touching the water with its feet, and rebounding from it like a flying-fish. I have only seen it singly.

33. *Procellaria gigantea* (Gm.)—Giant Petrel.—Not uncommon on the South African coast. At the anchorages of East London and Natal a pair is often seen among the shipping picking up scraps and offal. Any attempt to catch one with a hook and line proved unsuccessful; they would hold on until they were lifted off the water, and then let go. They have the strong odour peculiar to this class of birds in a very marked degree.

34. *Œstrelata mollis*, Gould—Soft-plumaged Petrel.—Not very common; generally seen in the South Atlantic from Lat. 15° to 20° S. It has very long wings, and flies swiftly and gracefully. It seems shy, and never comes near the coast.

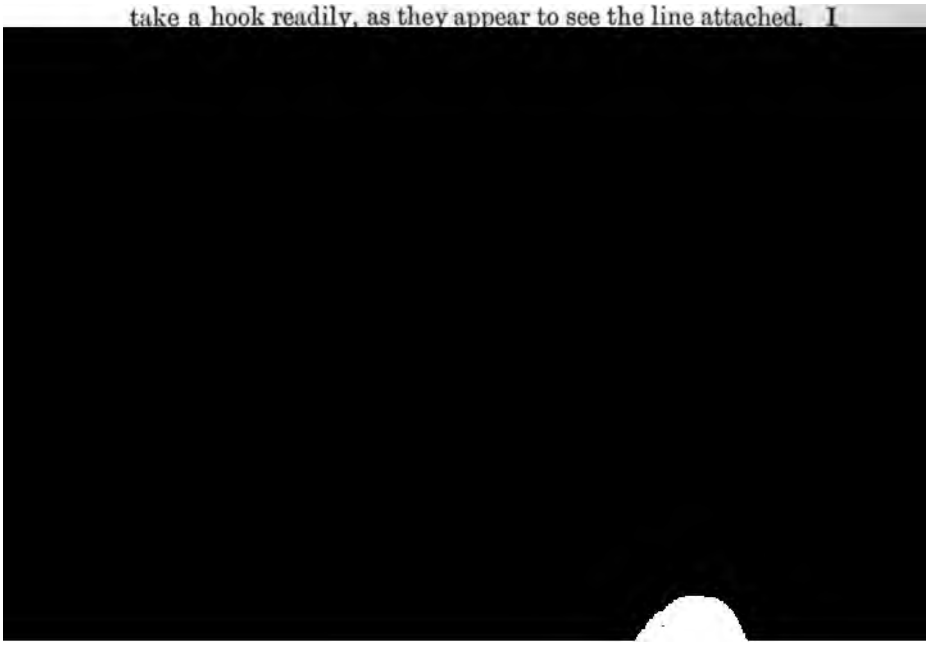
35. *Œstrelata macroptera* (Smith)—Long-winged Petrel.—I once saw two off Duyker Point, South Africa.

36. *Halobæna cærulea* (Gm.)—Blue Petrel, Ice Bird.—Pretty common on the Cape coast and north as far as Lat. 25° S.

37. *Procellaria atlantica*, Gould—Sooty Petrel.—This species, distinguished from the giant petrel by its smaller size, brown colour, and the absence of the white patch under the bill, is generally seen far out at sea from Lat. 15° to 33° S.

38. *Bulweria columbina* (Moq.-Tand.)—Bulwer's Petrel.—I have only seen this bird near Madeira and the neighbouring island of Porto Santo. I have frequently passed these islands without seeing a single specimen, and at other times I have seen five or six together. They appear to have rather longer wings in proportion than the stormy petrel; their flight is swift and easy.

39. *Majaqueus æquinoctialis* (L.)—Black Petrel, Cape Hen.—Very common on the coast, and at the anchorages of East London and Natal. They are very bold and fearless, coming close alongside vessels to pick up stray morsels, but will not take a hook readily, as they appear to see the line attached. I



Stanford University Libraries

after a gale, when they greedily devour almost anything. A few are seen at times on the Cape coast sometimes as far north as Natal, chiefly after bad weather.

41. *Prion vittatus* (Gm.)—Broad-billed Blue Petrel.—Fairly common round the Cape coast, but chiefly found farther south, where it appears in large flocks, flying close to the water like the stormy petrel. It never follows ships like other species, and thus I have not seen any caught. It is seen occasionally as far north as Lat. 25° S., but is not common there.

42. *Prion desolatus* (Gm.)—Narrow-billed Blue Petrel.—In habits and appearance very similar to the last; it is seen in the same localities, and is pretty common about the Cape.

43. *Diomedea exulans*, Linn.—Wandering Albatross.—Generally seen far out at sea, although I have seen one or two on the South African coast. We seldom see them farther north than Lat. 20° S. They do not follow steamers, but circle about in the distance.

44. *Diomedea melanophrys*, Temm.—Mollyhawk.—This and the next species of albatross are generally at sea classed as "Mollyhawks," the difference not being obvious at a distance. On the Cape voyage they are generally first seen about Lat. 25° S., and become more common as we proceed south. Round the Cape they are one of the commonest of species, and the vessel frequently passes through flocks of them swimming. Their food is apparently small fish or floating spawn. In Table Bay they are frequently caught by the Malays, who eat them. If properly cooked they taste not unlike hare. Farther south they feed on squid, and also follow ships in numbers for the scraps thrown overboard. They are particularly fond of fat pork, and may be often caught on a hook baited with a morsel of it.

45. *Diomedea chlororhyncha* (Gm.)—Yellow-nosed Albatross or Mollyhawk.—Resembling in appearance and habits the last species, this is not quite so common on the coast.

46. *Stercorarius crepidatus* (Banks)—Richardson's Skua.—Pretty common in the Tropics, where I have seen it sometimes singly, and sometimes in pairs or in small companies. They are shy, and never follow the ship or come very close.

47. *Stercorarius pomatorrhinus* (Temm.) — Pomatorrhine Skua.—One seen in Lat. 32° S., Long. 16° E.

48. *Stercorarius catarrhactes*, Linn.—Common Skua.—Seen once or twice, but not common.

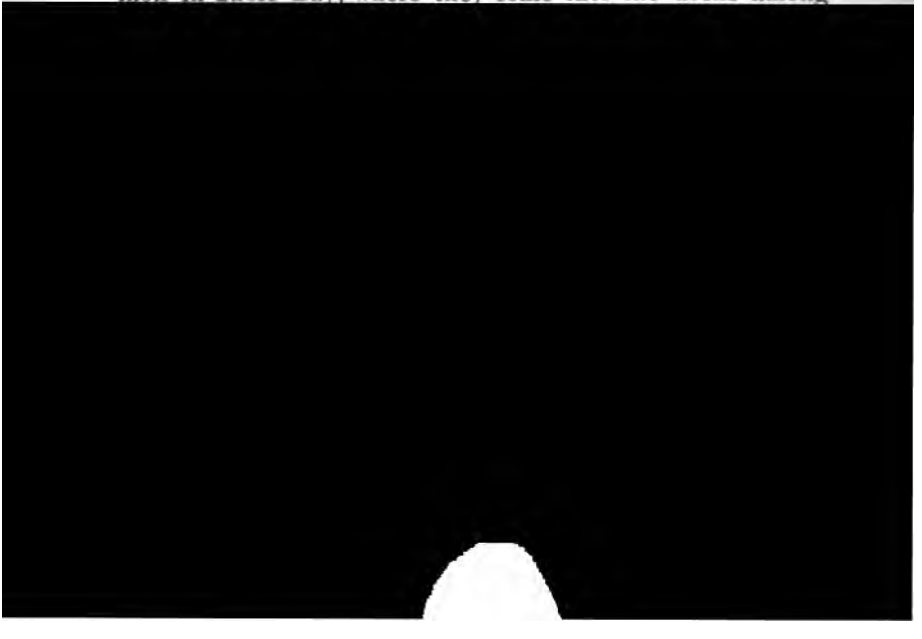
49. *Stercorarius antarcticus*, Less.—Antarctic Skua.—Fairly common on the South African coast. A pair is frequently seen in Algoa Bay, where they are in company with *Larus dominicanus*. I have never seen them molest the latter, who generally keep at a respectful distance.

50. *Larus canus*, Linn.—Common Gull.—Plentiful near Plymouth, but it does not appear to go far out to sea, as we never see it after the first day out.

51. *Larus dominicanus*, Licht.—Southern Black-backed Gull.—Almost identical in size and plumage with *Larus fuscus*, this species is very common in Algoa Bay and all along the coast east of the Cape of Good Hope, but they are seldom seen near Cape Town, where *Larus hartlaubi* takes its place. They breed on St Croix, a small island in Algoa Bay, and are said to destroy their eggs if their nests are disturbed.

52. *Larus argentatus*, Gmel.—Herring Gull.—Common in the Channel like the common gull; it is also plentiful about Madeira and the Canary Islands.

53. *Larus hartlaubi*, Burch—Hartlaub's Gull.—Very common in Table Bay, where they come into the docks among



Stanford University Libraries

58. *Sterna fuliginosa*, Gm.—Sooty Tern.—Chiefly seen near Ascension, well known as one of its principal nurseries.

59. *Anous stolida*, Linn.—Noddy Tern.—Very common at St Helena, where it is usually seen in large flocks.

60. *Phæthon æthereus*, Linn.—White-tailed Tropic Bird.—I have seen one or two near St Helena, but where they do not appear to be common.

61. *Sula bassana* (Linn.)—Common Gannet.—A few are generally seen in the Channel, but seldom after the first day out.

62. *Sula capensis*, Licht.—Cape Gannet.—Very common on the Cape coast; this species is not seen out of sight of land. They are not unlike the common gannet in appearance, the chief distinction being the black colour of the tail and large wing feathers. Their mode of fishing is the same, plunging into the water from a great height. They breed in great numbers on Bird Island, some distance north of Algoa Bay.

63. *Sula leucogaster*, Bodd.—Booby.—Sometimes seen in the Tropics, where it frequently alights on the yards and falls asleep, and may then sometimes be caught by hand. They bite severely if not cautiously taken.

64. *Phalacrocorax carbo* (Linn.)—Common Cormorant.—Not very common off the Cape.

65. *Phalacrocorax capensis*, Sparrm. — Cape Cormorant, Duyker.—In appearance nearly identical with our shag, these birds are very common in Table Bay, but are never seen more than three or four miles from land except in a fog, when a stray one is sometimes seen flying round the ship at a greater distance off shore. In Cape Town docks they swarm, chasing fish among the ships and perching on the buoys. Large flocks pass Green Point Lighthouse morning and evening, going to and from their fishing grounds. I have not yet been able to discover where they breed, but suspect it to be on Dassen Island or the neighbourhood.[1] They are not uncommon on the south-east coast, although occasionally seen.

66. *Phalacrocorax lucidus*, Licht.—South African or White-breasted Cormorant.—Seen occasionally about Table Bay.

[1] [Layard says they breed on Pomona Island and all the small rocks along the coast.—J. J. D.]

XVII. *Contributions to a Bibliography of the* "Sea Serpent."

By WILLIAM E. HOYLE, Esq., M.A.(Oxon.), F.R.S.E.

(Read 21st April 1886.)

The subjoined bibliography makes no pretensions whatever to completeness; it consists merely of a number of titles which came in the compiler's way while studying the subject, and which are here printed in a collected form in the hope that they may be the means of saving time and labour on the part of others.

Those references which the compiler has himself verified are indicated by an asterisk, the remainder are taken at second hand from more or less reliable sources. The author's thanks are due to Messrs John Gunn and William Evans, F.R.S.E., for a number of newspaper cuttings relating to the subject.

B.C. ? DIODORUS SICULUS, Bibliotheca historica, lib. iii.*

A.D.

77. PLINIUS, Historia naturalis, lib. viii., cap. 14.*

1555. OLAUS MAGNUS, Historia gentium septentrionalium, lib. xxi., cap. 24.

1741. EGEDE, H., Det gamle Grönlands nye Perlustratione, Copenhagen; *English translation*, A Description of Greenland, pp. 86-89, London, 1745.*

(?) EGEDE, P., Efterretninger om Grönland, pp. 45, 46, Copenhagen,

Stanford University Libraries

1819. Peck, W. D., Observations on the Sea Serpent, *Quart. Journ. Sci. Lit. and Arts R. Inst.*, vii., pp. 63-72; *Isis*, pp. 1123-1125.
Prince, J., Americanische Meerschlange, *Isis*, pp. 1754-1756.
Say, T., Ueber die Meerschlange von America, *Isis*, p. 653, 1819.
———, On the American Sea Serpent, *Quart. Journ. Sci. and Arts R. Inst.*, vi., pp. 163-165.
1820. Bigelow, J., Documents and Remarks respecting the Sea Serpent, *Amer. Journ. Sci.*, ii., pp. 147-164.*
1821. ———, On the American Sea Serpent, *Tilloch's Phil. Mag.*, lvii., pp. 356-359.*
1827. Hooker, Additional Testimony respecting the Sea Serpent in the American Seas, *Edinburgh Journal of Science*, vi., pp. 126-133.* Translation, *Froriep's Notizen*, xvii., 356, pp. 49-54.
Warburton, W., The American Sea Serpent, *Amer. Journ. Sci.*, xii., pp. 375, 376.*
1829. Mitchill, S. L., The History of Sea Serpentism, extracted from Samuel L. Mitchill's summary of the progress of Natural Science within our United States for a few years past; read before the New York Lyceum, at a succession of sittings during October 1828. No. 35. The Sea Serpent, *Amer. Journ. Sci.*, xv., pp. 351-356.*
1830. Deland, Ueber die Seeschlange, *Froriep's Notizen*, xxvii., 589, pp. 265, 266.
1834. Silliman, B., Ueber die Seeschlange, *Froriep's Notizen*, xl., 879, p. 328.
1839. Jardine, *Naturalists' Library*, viii., Marine Amphibia, p. 314, London.
1841. Rathke, H., Ueber die Seeschlange der Norweger, *Archiv f. Naturgesch.*, vii., 1, pp. 278-288.
1847. Cogswell, *Zoologist*, v., pp. 1841, 1911.*
Deinbolt, P. W., *Zoologist*, v., p. 1604.*
———, Sea Serpent, *Zoologist*, v., pp. 1714, 1715.*
1848. M'Quhæ, P., *Times*, Oct. 9, 1848.
,, *Illust. Lond. News*, p. 265, Oct. 28.*
,, Reply to Owen, *Times*, Nov. 21.*
Owen, R., The Great Sea Serpent, *Times*, Nov. 9; *Ann. Mag. Nat. Hist.* (2), ii., pp. 458-463.*
Stirling, J. D. M., *Illust. Lond. News*, Oct. 28.
1849. Herriman, Captain, *Sun*, July 9.
Hope, Hon. G., *Zoologist*, vii., p. 2356.*
Newman, E., The Sea Serpent (?), *Zoologist*, vii., p. 2395.*
Sandford, Lieutenant, *Zoologist*, vii., p. 2459.*
1850. ———, Romance of the Sea Serpent or Ichthyosaurus; also a collection of the ancient and modern authorities, with letters from distinguished merchants and men of science, 172 pp., Cambridge, U.S.A.
1857. Traill, T. S., On the supposed Sea Snake, cast on shore in the Orkneys in 1808, and the animal seen from H.M.S. "Dædalus" in 1848, *Proc. Roy. Soc. Edin.*, iii., pp. 208-215 (1854).*
1858. Harrington, Captain, *Times*, Feb. 5.
Smith, F., *Times*, February.

1859. Gosse, P. H., The Romance of Natural History, p. 345, etc., 8vo, London.*

1870. Buckland, F., The Sea Snake Again, *Land and Water*, April 9.*

1872. ,, Remarks on T. T.'s Letter, *Land and Water*, p. 158, Sept. 7.*

Cobbin, J., On a Sea Serpent, *Nature*, vi., p. 130.*

T. T., The Sea Serpent in a Highland Loch, *Land and Water*, p. 158, Sept. 7.*

———, On a Large Ribbon-Fish (*Gymnoterus*), *Nature*, vi., p. 270.*

1873. ———, *Scotsman*, November.

1875. Penny, Rev. E. L., Battle between a Whale and a Sea Serpent, *Illust. Lond. News*, lxvii., p. 515, Nov. 20.*

1876. Wilson, Andrew, *Scotsman*, June.

,, *Good Words*, pp. 838-845, December.

1877. Adams, J., Account of a supposed Sea Serpent seen off Nepean Island, *Proc. Lit. Phil. Soc. Liverpool*, No. xxxi., pp. lxviii., lxix.*

Buckland, F., Occurrence of a Sea Serpent, *Land and Water*, Sept. 8.*

Cornish, T., Reply to Buckland, *Land and Water*, p. 220, Sept. 15.*

Haynes, Lieut., The Sea Monster seen from H.M.S. "Osborne," *Graphic*, June 30.*

"Nahanik," The Great Sea Serpent, *Land and Water*, p. 220, Sept. 15.*

Proctor, R. A., Strange Sea Monsters, *Echo*, Jan. 15.

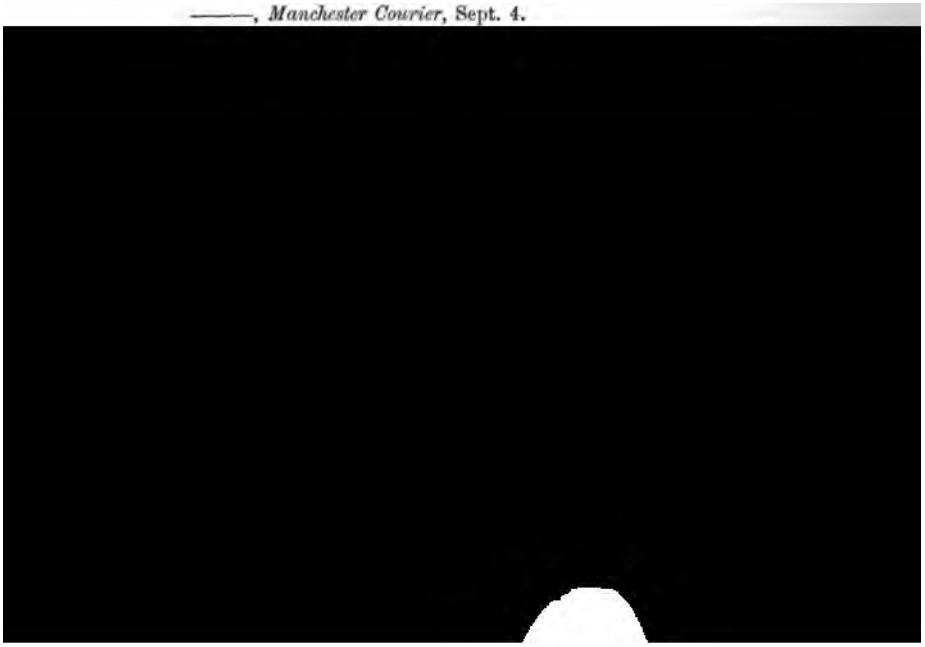
,, *Gentleman's Magazine*, March.

Webster, J. K., The Sea Monster, *Advertiser and Ladies' Journal*, Jan. 6; from the *London and China Telegraph*.*

Wilson, Andrew, The Sea Serpents of Science, *Land and Water*, pp. 218-220, Sept. 15.*

,, *Times*, June 15.*

———, *Manchester Courier*, Sept. 4.



Stanford University Libraries

1883. Aldis, W. S., The Sea Serpent, *Nature*, xxvii., p. 338.*
Barfoot, W., The Sea Serpent, *tom. cit.*, p. 338.*
Lee, H., Sea Monsters Unmasked, *Fisheries' Exhibition Handbook*, pp. 52-103, 8vo, London, 1883.*
Mott, F. T., The Sea Serpent, *Nature*, xxvii., p. 293.*
Rae, J., The Sea Serpent, *tom. cit.*, p. 366.*
Sidebotham, J., The Sea Serpent, *tom. cit.*, p. 315.*
1884. Henderson, T. G., *Inverness Courier*, Sept. 14.*
Morris, A., A Sea Monster, *Nature*, xxx., p. 513.*
1885. Reid, W., History of Sea Serpents, *John O'Groat Journal*, July 29 to Sept. 6.*
———, The Sea Serpent again, *Scotsman*, Sept. 1.*
1886. ———, The Sea Serpent again, *Evening Dispatch*, Edinburgh, Sept. 15.*
Hoyle, W. E., Article, "Sea Serpent," *Encycl. Brit.*, ed. 9.

XVIII. *A Catalogue of Recent Cephalopoda.* By William E. Hoyle, Esq., M.A.(Oxon.), F.R.S.E.

(Read 17th March 1886.)

The latest attempt to give a complete systematic account of the Cephalopoda is that of Tryon, published in 1879; but it labours under several disadvantages—the first and most serious being that the author has given almost all his attention to Conchology properly so-called, and has apparently treated the Cephalopods rather with a view of making his Manual complete than from any special interest in them; secondly, the mode of arrangement adopted of placing all the synonymy in the form of an alphabetical index at the end of the volume, renders it exceedingly difficult to ascertain what he includes under each species; and, furthermore, a large number of new forms have been described since the publication of his work, and several important contributions have been made to our knowledge of the relations of previously described groups.

Under these circumstances it appeared that the compilation of such a list as the present, even though it might fail—indeed necessarily must fail—to give a completely satisfactory survey of the class, would nevertheless be of considerable use to workers in this interesting branch of Malacology, were it only as a reliable index to the literature of the subject, and I therefore resolved to draw up in a form fit for publi-

cation the material gathered for use in my own investigations. I should, however, be doing injustice to Mr Tryon did I not acknowledge my indebtedness to his elaborate and careful index.

At present no systematic treatment of the whole class of Cephalopoda can hope to be other than provisional. Such a large percentage of the published descriptions of species are inaccurate or insufficient for modern requirements, that nothing satisfactory can be obtained until some worker shall travel to the various museums and re-examine all such type specimens as are at present extant; and it would be particularly desirable that he should have the opportunity of comparing the different specimens side by side.

With respect to the list itself, I have endeavoured to give a reference to the original creation of each species and such others as might be necessary to indicate the important points in its history, or good descriptions and figures of it; save in one or two cases of special interest, I have not attempted to give complete synonymies. I have especially avoided registering species as identical without such evidence as seemed to me conclusive, for, so far from tending to simplicity and clearness, hasty and indiscriminate identifying of species can only lead to the utmost confusion. It is too much to hope that there should be no mistakes in the references but

Stanford University Libraries

genera; hence it may be said in round numbers that we are acquainted with 50 or 60 genera of recent Cephalopoda containing 300 species. It is worthy of remark that 29, or half the genera, contain only one species each, while nearly one-half the species, 170, belong to the three genera *Octopus*, *Sepia*, and *Loligo*.

As regards their distribution the Cephalopoda seem to be divisible into three groups—(1) the Pelagic, (2) the Abyssal, and (3) the Littoral.

The first two of these have been united under the name "Oceanic" species, and have been disposed in three groups corresponding to the Atlantic, Pacific, and Indian (including the Southern) Oceans, rather for convenience than from a belief that such a division is natural, although the great majority are confined to one area. The chief factor limiting their spread is probably temperature, though doubtless other conditions, such as the presence of Gulf weed, also have their influence.

The "Littoral" species, that is, those found in moderately shallow water not far from the coasts, whether they be active swimmers like *Loligo*, or more sedentary like *Octopus*, are much more restricted in their range than the oceanic. For the purpose of representing their distribution, the coasts of the world have been divided into seventeen regions, which are very different in extent and in the number of species that have been recorded from them. As regards the former of these points it may be remarked that no sharp boundaries can be drawn between them at all; for, although for statistical purposes it may be necessary to adopt lines of demarcation, these are not recognised by nature, and, furthermore, a fuller knowledge of the faunas of the various regions would almost certainly show that some of the districts here proposed should be subdivided and others united.

The geographical regions here adopted agree very closely with those proposed by Dr Paul Fischer in his recent Manual,[1] based upon a study of the whole of the Mollusca; their names and boundaries are as follows:—

1. *The Scandinavian Region* includes the whole of the

[1] Manuel de Conchyliologie, 8vo, Paris.

Scandinavian Peninsula, Denmark, Holland, Iceland, and the northern half of the British Isles.

2. *The New England Region.*—The northern boundary of this region I am unable to fix, probably it extends up to the coast of Labrador; southwards it extends about as far as Cape Hatteras.

3. *The West Indian Region* extends southwards from the last, about as far as the mouth of the Rio de la Plata, and includes the Gulf of Mexico and the shores of the islands at its mouth.

4. *The Lusitanian Region* includes the southern half of the British Isles, the coasts of France, Spain, and Africa, about as far as the Canary Islands. It is, of course, closely related to the Mediterranean Region, but that sea contains so many forms peculiar to it that it appeared best to regard it provisionally as a distinct region.

5. *The Mediterranean Region* consists of the Mediterranean and Black Seas. Strictly speaking, here also a subdivision should be made, like that adopted in regard to the oceans, separating the pelagic from the littoral forms; but the distinction does not seem to be so clearly marked, perhaps owing to the subject not having been sufficiently investigated.

6. *The West African Region* extends from the Canaries to about the Tropic of Capricorn.

Stanford University Libraries

10. *The Japanese Region.*—The coasts of these islands have yielded so many remarkable Cephalopods that it seems advisable to separate them, provisionally at all events, as a distinct region.

11. *The Australian Region.*—The coast of the whole Australian continent is here regarded as forming a single region; as above remarked, it is quite probable that the northern portion of it should be placed in the last division but one, but so little information regarding the species from that district has come into my hands, that I forbear from drawing any line. Fischer makes an arbitrary boundary at the Tropic of Capricorn.

12. *The New Zealand Region.*—The Cephalopod fauna of these islands is so peculiar that it seems advisable to separate them from the Australian region, to which they are no doubt nearly allied, though the number of forms proved to be common to both is very few.

13. *The Pacific Insular Region.*—The shores of the various archipelagos in the Pacific Ocean seem to be inhabited by numerous Cephalopods which are quite distinct from the pelagic forms inhabiting the open ocean. But few collections have as yet been made of these—not enough to enable any general conclusions regarding their affinities to be drawn.

14. *The Californian Region* stretches from the peninsula of Alaska to the Isthmus of Panama; probably it will eventually be necessary to subdivide it, but so few forms have been described from that coast, that this course hardly seems advisable at present. From the coast between Alaska and Kamtschatka no Cephalopods are known to me; probably they will be found, like the other Mollusca from that region, to be of Arctic types.

15. *The Peruvian Region.*—The northern boundary of this province may be taken at the Isthmus of Panama, and the southern at about the northern limit of Patagonia.

16. *The Patagonian Region* includes the extremity of South America, both on the eastern and western coasts.

17. *The Arctic Region.*—The coasts of Greenland, Spitzbergen, and the seas within the Arctic circle, so far as they have been explored, constitute this region.

The species which have been reported from the Oceanic areas are distributed thus:

66	species	are recorded from	only one Oceanic area.
15	,,	,,	two Oceanic areas.
3	,,	,,	three ,,

These numbers show that about 75 per cent. of the oceanic forms are confined to one ocean, and that cosmopolitan forms must be regarded as exceptional.

The species occurring in the seventeen Littoral regions may be arranged thus:

199	species	are recorded from	only one Littoral area.
27	,,	,,	two Littoral areas.
12	,,	,,	three ,,
4	,,	,,	four ,,
1	,,	,,	five ,,
2	,,	,,	six ,,
1	,,	,,	ten ,,

About 80 per cent. therefore of these forms are confined to one region—a striking confirmation of the proposition that littoral forms in general belong to many species, each of which is confined within narrow limits.

Thirty-five species are recorded from both Oceanic and Littoral regions, but the majority of these are typically pelagic, and hence their occurrence in the latter areas must

Stanford University Libraries

Class **CEPHALOPODA**, Cuvier.

Siphonopoda, Lankester.

Order I. **DIBRANCHIATA**, Owen, 1832.

Suborder I. OCTOPODA, Leach, 1818.

Division 1. Lioglossa,[1] Lütken, 1882.

Family I. Pteroti, Reinhardt et Prosch, 1846.

Cirroteuthidæ, Keferstein.

Cirroteuthis, Eschricht, 1836.

Sciadephorus, Reinhardt et Prosch, 1846.
Bostrychoteuthis, Agassiz, 1846.

1. **C. Mülleri**, Eschr., Nova Acta Acad. Cæs. Leop.-Carol., xviii., p. 627, pls. xlvi.-xlviii., 1836.
   1846. *Sciadephorus Mülleri*, Reinh. og Prosch, Om Sciadephorus Mülleri, Kjöbenhavn.[2]
   Arctic Region (Greenland).
2. **C. umbellata**, Fischer, Journ. de Conch., xxiii., p. 402, 1883.
   Atlantic Ocean.
3. **C. magna**, Hoyle, Diagnoses I., p. 233, 1885; Chall. Ceph., p. 56, pl. xi., figs. 3-5; pl. xii.; pl. xiii., figs. 1-4, 1886.
   Southern and Pacific Oceans.
4. **C. pacifica**, Hoyle, Diagnoses I., p. 235, 1885; Chall. Ceph., p. 61, pl. x., 1886.
   Pacific Ocean.
5. **C. meangensis**, Hoyle, Diagnoses I., p. 234, 1885; Chall. Ceph., p. 63, pl. ix., figs. 12, 13; pl. xi., figs. 1, 2; pl. xiii., figs. 5, 6, 1886.
   Pacific Ocean.
6. **C. plena**, Vll., Third Catal., p. 404, pl. xlii., fig. 3, 1885.
   Atlantic Ocean.
7. **C. megaptera**, Vll., Third Catal., p. 405, pl. xliii., figs. 1, 2, 1885.
   Atlantic Ocean.

Stauroteuthis, Verrill, 1879.

1. **S. syrtensis**, Vll., Amer. Journ. Sci., xviii., p. 468, 1879; Ceph. N. E. Amer., p. 382, pl. xxxii., figs. 1-5, 1881.
   Atlantic Ocean; New England Region.

[1] Without a radula (Dyreriget, p. 543, Kjöbenhavn, 1881-82).
[2] *K. dansk. Vidensk. Selsk. Afhandl.*, Bd. xii., pp. 185-224, pls. i.-v.

Opisthoteuthis, Verrill, 1883.

1. **O. Agassizii**, Vll., "Blake" Suppl., p. 113, pl. i., fig. 1; pl. ii., fig. 1, 1883.

Atlantic Ocean; New England and West Indian Regions.

Division 2. Trachyglossa, Lütken,[1] 1882.

Family II. AMPHITRETIDÆ, Hoyle, 1886.

Amphitretus, Hoyle, 1885.

1. **A. pelagicus**, Hoyle, Diagnoses I., p. 235, 1885; Chall. Ceph., p. 67, pl. ix., figs. 7-9, 1886.

Pacific Ocean.

Family III. ARGONAUTIDÆ, Cantraine, 1841.

Argonauta, Linné,[2] 1756.

Ocythoë, Leach et Auctt. (*non* Rafinesque).

1. **A. argo**, Linn., Syst. Nat., ed. x., p. 708, 1758.

1817. *Argonauta haustrum*, Dillwyn, Descr. Catal., p. 335.
1838. ,, *argo*, d'Orb., Céph. acét.; Argonaute, pl. ii., figs. 1, 2.
1853. ,, *Gruneri*, Dkr., Zeitschr. f. Malak., 1852, p. 48.
1861. ,, ,, Rv., Conch. Icon., pl. iii., fig. 2*b*.
1861. ,, *argo*, Rv., Conch. Icon., pl. iii., fig. 2*c*.
1861. ,, *haustrum*, Rv., Conch. Icon., pl. ii.
1886. ,, *argo*, Hoyle, Chall. Ceph., p. 69.

Atlantic and Pacific Oceans; New England, Lusitanian, Mediterranean, South African, Indo-Malayan, and Aus-

Stanford University Libraries

1787. *Argonauta oryzata*, Meuschen, Mus. Gevers., 252, No. 133.
1817. ,, *gondola*, Dillwyn, Descr. Catal., p. 335.
1822. ,, *tuberculosa*, Lmk., Anim. s. vert., vii., p. 652.
1861. ,, ,, Rv., Conch. Icon., pl. i.

Pacific Ocean; South African, Indo-Malayan, Australian, and New Zealand Regions.

3. **A. hians**, Solander, Portl. Catal., p. 44, lat. 1055 (vol. ii., p. 113),[1] 1786.

1822. *Argonauta nitida*, Lmk., Anim. s. vert., vii., p. 653.
1850. ,, *Owenii*, Ad. and Rv., Voy. "Samarang," Moll, pl. iii., fig. 1.
1850. ,, *gondola*, Ad. and Rv., *op. cit.*, pl. ii.
1852. ,, *Kochiana*, Dunker, Zeitschr. f. Malak., p. 49 (= var.).
1861. ,, *gondola*, Rv., Conch. Icon., pl. iv., figs. 3*a*, 3*b*.

Atlantic and Pacific Oceans; Indo-Malayan Region.

4. **A. pacifica**, Dall, Amer. Journ. Conch., vii., p. 95, 1872.

Californian Region.

5. **A. expansa**, Dall, Proc. Calif. Acad., N.S., iv., p. 303, 1873.

Californian Region.

6. **A. Bœttgeri**, Maltzan, Journ. de Conch., xxix., p. 163, pl. ix., fig. 7, 1881.

Hab.?

7. **A. gracilis**, Kirk, Trans. N. Zeal. Inst., xvii., p. 58, pl. xiii., 1885.

New Zealand Region.

Ocythoë, Rafinesque, 1814 (*non* Leach et auctt.).

Parasira, Steenstrup.

1. **O. tuberculata**, Rafinesque,[2] Précis découv. somiol., p. 29, 1814.

1828. *Octopus catenulatus*, Fér., Céph. acét., pl. vi. *bis et ter.*
1837. ,, *Carenæ*, Vér., Mem. Accad. Sci. Torino (2), i., p. 92, pl. ii.

[1] I have not had an opportunity of seeing the original Portland Catalogue, but the references in brackets are taken from a copy of Solander's MS. in the Linnean Society's Library, for the knowledge of which I am indebted to Dr Murie; it was written by Humphreys, and was formerly in the possession of G. B. Sowerby, from whom it was purchased for the sum of £5.

[2] It seems very improbable that this is the *Octopus tuberculatus* of Risso (Hist. Nat. Eur. Mérid., t. iv., p. 3, 1826); his description does not seem to me applicable to this form, in addition to which we have Vérany's statement (Céph. médit., p. 40) that Risso did not recognise the drawing of *Octopus catenulatus* (*op. cit.*, pl. xiii.) as his species. There can, however, be no doubt that, as Steenstrup has recently pointed out (*loc. cit.*), this is the species which Rafinesque had in view in constituting the genus *Ocythoë*, which Leach and others have always understood to be the animal of the Argonaut, which Rafinesque clearly states was not the case ("Good Book," *loc. cit.*).

1838. *Philonexis tuberculatus*, d'Orb., Céph. acét., p. 87, pl. vi. *bis et ter*, pl. xxiii.
1840. *Ocythoë tuberculata*, Raf., Good Book, p. 63.
1851. *Octopus catenulatus*, Vér., Céph. médit., p. 37, pl. xiii.
1851. ,, *Carena*, Vér., Céph. médit., p. 34, pl. xiv., figs. 2, 3; pl. xli., figs. 1, 2.
1861. *Parasira catenulata*, Stp., Vid. Meddel. nat. Foren. Kjöbenhavn, 1860, p. 333.
1869. ,, ,, Targ., Cef. Mus. Firenze, p. 11.
1869. ,, *tuberculata*, Targ., *op. cit.*, p. 13.
1880. *Ocythoë* ,, Stp., Ommat. Blækspr., p. 104.
1881. *Parasira catenulata*, Vll., Ceph. N. E. Amer., p. 362, pl. xxxiii., fig. 2.

New England and Mediterranean Regions.

Family IV. PHILONEXIDÆ, d'Orbigny, 1838.

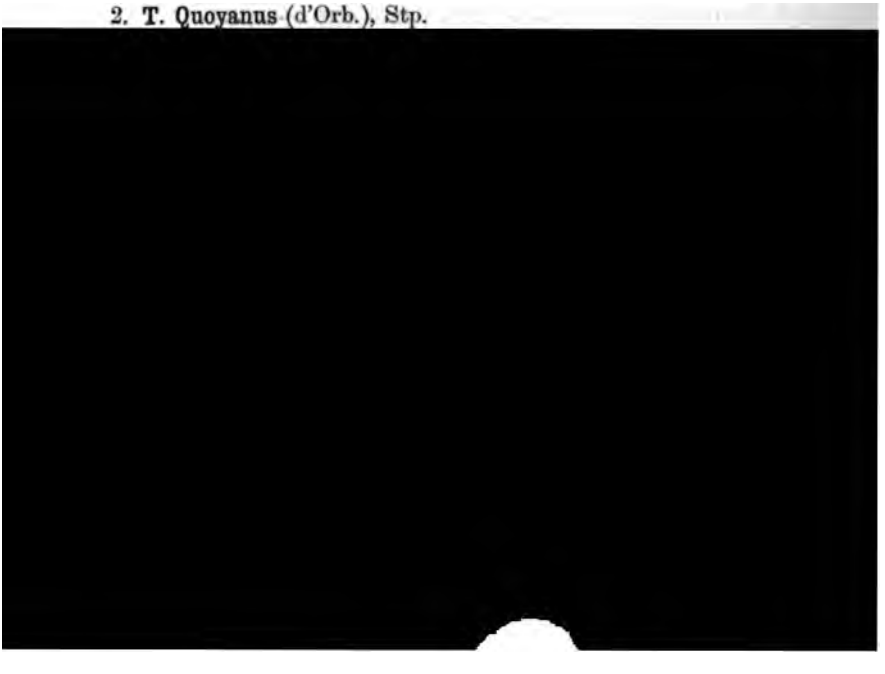
Tremoctopus, delle Chiaje, 1830.

Philonexis, d'Orbigny.

1. **T. violaceus**, d. Ch., Mem. stor. nat., pl. lxx. (*fide* Vér.), 1830.
1830. *Octopus velifer*, Fér., Poulpes, pls. xviii., xix. (*nomen tantum*).
1837. ,, *velatus*, Rang, Mag. de Zool., cl. v., p. 60, pl. lxxxix.
1838. *Philonexis velifer*, d'Orb., Céph. acét., p. 91, pls. xviii.-xx., pl. xxiii., figs. 2-4.
1851. *Tremoctopus* ,, Vér., Céph. médit., p. 41, pl. xiv., fig. 1.
1851. ,, *violaceus*, Vér., *op. cit.*, p. 41, pls. xv., xvi.

Mediterranean Region.

2. T. Quoyanus (d'Orb.), Stp.



Stanford University Libraries

1861. *Tremoctopus alanticus*, Stp., Vid. Meddel. nat. Foren. Kjöbenhavn, 1860, p. 332 (*err. typ.*).
1886. ,, *atlanticus*, Hoyle, Chall. Ceph., p. 71.
Atlantic Ocean.

5. **T. microstomus** (Reynaud), Tryon.
1830. *Octopus microstomus*, Reyn., Mag. de Zool., cl. v., p. 23, pl. xxiii.
1838. *Philonexis* ,, d'Orb., Céph. acét., p. 100, pl. x., fig. 5.
1851. *Octopus Koellikeri* (*?*), Vér., Céph. médit., p. 33, pl. xi., figs. A, B, C.
1879. *Tremoctopus microstomus*, Tryon, Man. Conch., i., p. 130.
Atlantic Ocean; Mediterranean Region.

6. **T. hyalinus** (Rang), Tryon.
1837. *Octopus hyalinus*, Rang, Mag. de Zool., cl. v., p. 66, pl. xcii.
1838. *Philonexis* ,, d'Orb., Céph. acét., p. 104, pl. xvi., figs. 1-3.
1879. *Tremoctopus* ,, Tryon, Man. Conch., i., p. 131.
Atlantic Ocean.

7. **T. ocellatus**, Brock, Zeitschr. f. wiss. Zool., xxxvi., p. 601, pl. xxxvii., figs. 1, 2, 1882.
Mediterranean Region.

8. **T. semipalmatus**, Owen, Trans. Zool. Soc. Lond., ii., p. 112, pl. xxi., figs. 12, 13, 1836.
Atlantic Ocean.

(Species insufficiently characterised.)

9. **T. dubius** (E. et S.), Tryon.
1851. *Philonexis dubia*, Vér., Céph. médit., p. 34.
1852. *Octopus dubius*, E. et S., Voy. "Bonite," p. 15, pl. i., figs. 10-14.
1879. *Tremoctopus dubius*, Tryon, Man. Conch., i., p. 131.

Family V. Alloposidæ, Verrill, 1881.

Alloposus, Verrill, 1880.

Haliphron (*?*), Steenstrup.

1. **A. mollis**, Vll.
1859. *Haliphron atlanticus*, Stp., Vid. Meddel. nat. Foren. Kjöbenhavn, 1858, p. 183.
1880. *Alloposus mollis*, Vll., Amer. Journ. Sci., xx., p. 394.
1881. ,, ,, Vll., Ceph. N. E. Amer., pp. 366, 420, pls. l., li., figs. 3, 4.
1886. ,, ,, Hoyle, Chall. Ceph., p. 72.
Atlantic Ocean; New England Region.

Family VI. Octopodidæ, d'Orbigny, 1838.

Octopidæ, d'Orb. (*pars*).

Octopus, Lamarck, 1799.

1. **O. vulgaris**, Lmk., Mém. Soc. Hist. Nat. Paris, i., p. 18, 1799.

1826. *Octopus breviten taculatus (?)*, Blv., Dict. d. Sci. Nat., xliii., p. 187.
1838. ,, *vulgaris*, d'Orb., Céph. acét., p. 26, pls. ii., iii. *bis*; pl. viii., figs. 1, 2; pls. xi.-xv.; pl. xxix., fig. 6.
1851. ,, ,, Vér., Céph. médit., p. 16, pl. viii.
1869. ,, *Troscheli (?)*, Targ., Cef. Mus. Firenze, p. 19.

Almost cosmopolitan.[1]

2. **O. Salutii**, Vér., Mem. Accad. Sci. Torino, p. 93, pl. iii., 1837; Céph. médit., p. 20, pl. ix., 1851.

Mediterranean Region.

3. **O. occidentalis**, Stp., MS.

1853. *Octopus vulgaris*, var. *americanus*, d'Orb., Moll. Cuba, p. 14, tab. i.
1886. ,, *occidentalis*, Hoyle, Chall. Ceph., p. 77.

West Indian and West African Regions.

4. **O. tuberculatus**, Blv., Dict. d. Sci. Nat., xliii., p. 187, 1826.

1886. *Octopus tuberculatus*, Hoyle, Chall. Ceph., p. 78.

West Indian, Mediterranean, and West African Regions.

5. **O. verrucosus**, Hoyle, Diagnoses I., p. 222, 1885; Chall. Ceph., p. 79, pl. iv., 1886.

South African Region.

6. **O. granulatus**, Lmk.[2]

1792. *Sepia rugosa*, Bosc, Actes Soc. Hist. Nat. Paris, i., p. 24, pl. v., figs. 1, 2.
1799. *Octopus granulatus*, Lmk., Mém. Soc. Hist. Nat. Paris, i., p. 20.
1838. ,, *rugosus*, d'Orb., Céph. acét., p. 45, pls. vi., xxiii., fig. 2.
1869. ,, *incertus*, Targ., Cef. Mus. Firenze, p. 22, pl. vi., figs. 9, 11.
1886. ,, *granulatus*, Hoyle, Chall. Ceph., p. 80.

Stanford University Libraries

9. **O. polyzenia**, Gray, B.M.C., p. 13, 1849.
   1884. *Octopus polyzenia*, E. A. Sm., "Alert" Rep., p. 34, pl. iv., fig. A.
   Australian Region.
10. **O. tonganus**, Hoyle, Diagnoses I., p. 225, 1885; Chall. Ceph., p. 83, pl. viii., figs, 1, 2, 1886.
   Pacific Insular Region.
11. **O. De Filippi**, Vér.
   1851. *Octopus De-Filippii*, Vér., Céph. médit., p. 30, pl. xi., figs. D, F.
   1869. ,, *De Filippi*, Targ., Cef. Mus. Firenze, p. 20.
   Mediterranean Region.
12. **O. vitiensis**, Hoyle, Diagnoses I., p. 226, 1885; Chall. Ceph., p. 84, pl. vii., figs. 6-8, 1886.
   Pacific Insular Region.
13. **O. bimaculatus**, Vll., "Blake" Suppl., p. 121, pl. v., fig. 1; pl. vi., 1883.
   Californian Region.
14. **O. marmoratus**, Hoyle, Diagnoses I., p. 227, 1885; Chall. Ceph., p. 85, pl. vi., 1886.
   Pacific Insular Region.
15. **O. areolatus**, de Haan, MS., 1835 (*fide* d'Orb.).
   1838. *Octopus areolatus*, d'Orb., Céph. acét., p. 65.
   1838. ,, *sinensis* (?), d'Orb., Céph. acét., p. 68, pl. ix.
   1849. ,, *ocellatus*, Gray, B.M.C., p. 15.
   1886. ,, ,, App., Japanska Ceph., p. 8, pl. i., figs. 1, 2, 3.
   1886. ,, *areolatus*, Hoyle, Chall. Ceph., p. 86, pl. iii., figs. 6, 7.
   Indo-Malayan and Japanese Regions.
16. **O. superciliosus**, Q. et G., Voy. "Astrolabe," ii., p. 88, pl. vi., fig. 4, 1832.
   1838. *Octopus superciliosus*, d'Orb., Céph. acét., p. 41, pl. x., fig. 3; pl. xxviii., fig. 6.
   Australian Region.
17. **O. australis**, Hoyle, Diagnoses I., p. 224, 1885; Chall. Ceph., p. 88, pl. iii., figs. 4, 5, 1886.
   Australian Region.
18. **O. membranaceus**, Q. et G., Voy. "Astrolabe," ii., p. 89, pl. vi., fig. 5, 1832.
   1882. *Amphioctopus membranaceus*, Fischer, Man. de Conch., p. 333.
   Indo-Malayan Region.
19. **O. carolinensis**, Vll., Second Catal., p. 235, 1884; Third Catal., pl. xlii., fig. 4, 1885.
   New England Region.
20. **O. horridus**, d'Orb., Tabl. méth., Ann. Sci. Nat., vii., pp. 54, 144, No. 4, 1826; Céph. acét., p. 51, pl. vii., fig. 3, 1838.

1848. *Octopus argus*, Krauss, Südafrik. Moll., p. 132, pl. vi., fig. 26.
South African and Red Sea Regions.

21. **O. aculeatus**, d'Orb., Céph. acét., pl. vii. (*nomen tantum*), 1825; Céph. acét., p. 53, pl. vii., figs. 1, 2; pl. viii., fig. 1; pl. xxiii., figs. 3, 4, 1838.
Indo-Malayan and Insular Pacific Regions.

22. **O. tenebricus**, E. A. Sm., "Alert" Rep., p. 35, pl. iv., fig. B, 1884.
Australian Region.

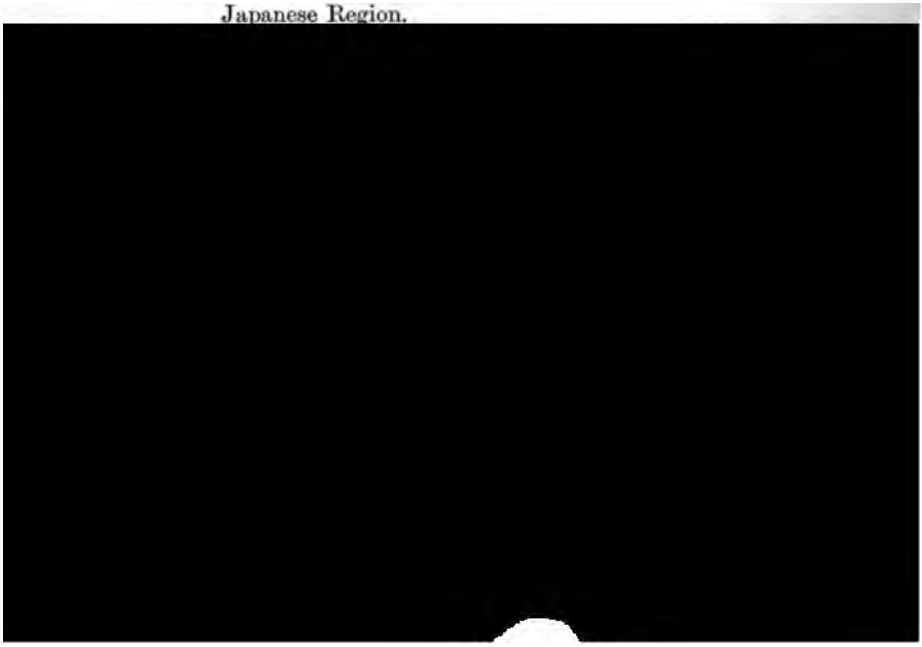
23. **O. megalocyathus**, Gld., Moll. Wilkes Exped., p. 471, fig. 586, 1852.
Patagonian Region.

24. **O. fontanianus**, d'Orb., Amér. mérid., p. 28, pl. ii., fig. 5, 1835; Céph. acét., p. 49; pl. xxviii., fig. 5; pl. xxix., fig. 1, 1838.
Peruvian and Patagonian Regions.

25. **O. tehuelchus**, d'Orb., Amér. mérid., p. 27, pl. i., figs. 6, 7, 1835; Céph. acét., p. 55, pl. xvii., fig. 6, 1838.
1871. *Octopus megalocyathus*, Cunningham, Trans. Linn. Soc., xxvii., p. 474.[1]
1886. ,, *tehuelchus*, Hoyle, Chall. Ceph., p. 89.
West Indian and Patagonian Regions.

26. **O. hawaiensis**, E. et S., Voy. "Bonite," p. 9, pl. i., figs. 1-5, 1852.
Pacific Insular Region.

27. **O. globosus**, App., Japanska Ceph., p. 7, pl. i., figs. 4, 5, 1886.
Japanese Region.



Stanford University Libraries

1886. *Octopus piscatorum*, Hoyle, Chall. Ceph., p. 91.

Atlantic Ocean ; Scandinavian and New England Regions.

33. **O. arcticus**, Prosch.[1]

1834. *Sepia gröenlandica* (*?*), Dewh., Nat. Hist. Cetacea, p. 263.
1849. *Octopus arcticus*, Prosch, K. d. Vid. Selsk. Skr. [5], i., p. 53, figs. 1-3.
1856. ,, ,, Stp., Hectocotyl., p. 201, pl. ii., fig. 2.
1873. ,, *Bairdii*, Vll., Amer. Journ. Sci., v., p. 5.
1878. ,, ,, Sars, Moll. Reg. Arct. Norv., p. 339, pl. xxxiii., figs. 1-10.
1881. ,, ,, Vll., Ceph. N. E. Amer., pp. 368, 421, pl. xxxiii., fig. 1 ; pl. xxxiv., figs. 5, 6 ; pl. xxxvi., fig. 10 ; pl. xxxviii., fig. 8 ; pl. xlix., fig. 4 ; pl. li., fig. 1.
1886. ,, *arcticus*, Hoyle, Chall. Ceph., p. 91.

Atlantic Ocean; Scandinavian, New England and Arctic Regions.

34. **O. Verrilli**, Hoyle.

1883. *Octopus pictus*, Vll., "Blake" Suppl., p. 112, pl. iii., fig. 3.
1886. ,, *verrilli*, Hoyle, Chall. Ceph., p. 10.

West Indian Region.

35. **O. pictus**, Brock, Zeitschr. f. wiss. Zool., xxxvi., p. 603, pl. xxxvii., fig. 3, 1882.

1883. *Octopus maculosus*, Hoyle, Proc. Roy. Phys. Soc. Edin., vii., p. 319, pl. vi.
1884. ,, ,, E. A. Sm., "Alert" Rep., p. 36, pl. iv., fig. c.
1886. ,, *pictus* et var. *fasciata*, Hoyle, Chall. Ceph., p. 92, pl. viii., fig. 3.

Australian Region.

36. **O. lunulatus**, Q. et G., Voy. "Astrolabe," ii., p. 86, pl. vi., figs. 1, 2, 1832.

1838. *Octopus lunulatus*, d'Orb., Céph. acét., p. 59, pl. x., fig. 2 ; pl. xxvi., figs. 5-7.

Pacific Insular Region.[2]

37. **O. aranea**, d'Orb., Céph. acét., pl. v. (*nomen tantum*), 1826 ; Céph. acét., p. 57, pl. v., 1838.

South African and Pacific Insular Regions.

[1] Verrill's description is so full, and his figures so numerous, that I cannot doubt that his species is the same as that of Prosch, the types of which I had an opportunity of examining in Copenhagen ; and Prof. Sars' beautiful drawing leaves equally little room for uncertainty. What Dewhurst's *Sepia groenlandica* really was will probably always remain unknown, the original description being quite inadequate.

[2] Hutton (Man. Moll. N. Zeal., p. 1) has corrected d'Orbigny's erroneous statement, that this species is from New Zealand ; Quoy and Gaimard say, "le havre Carteret à la nouvelle Irlande."

38. **O. bermudensis**, Hoyle, Diagnoses I., p. 228, 1885; Chall. Ceph., p. 94, pl. ii., fig. 5, 1886.
West Indian Region (Bermuda).

39. **O. macropus**, Risso,[1] Hist. Nat. Eur. mérid., iv., p. 3, 1826.
1826. *Octopus Cuvierii*, d'Orb., Céph. acét., pl. iv. (*nomen tantum*).
1838. ,, *Cuvieri*, d'Orb., Céph. acét., p. 18, pls. i., iv., xxiv., xxvii.
1851. ,, *macropus*, Vér., Céph. médit., p. 27, pl. x.
1869. ,, ,, Targ., Cef. Mus, Firenze, p. 23.
1869. ,, *Cuvieri*, Targ., *op. cit.*, p. 24.
1886. ,, ,, App., Japanska Ceph., p. 6, pl. i., fig. 6.
1886. ,, *macropus*, Hoyle, Chall. Ceph., pp. 11, 95.
Mediterranean, Red Sea, Indo-Malayan, and Japanese Regions.

40. **O. ornatus**, Gld., Moll. Wilkes Exped., p. 476, fig. 590, 1852.
Pacific Insular Region.

41. **O. gracilis**, Vll., Second Catal., p. 236, 1884.
Atlantic Ocean.

42. **O. bandensis**, Hoyle, Diagnoses I., p. 227, 1885; Chall. Ceph., p. 96, pl. vii., figs. 9, 10, 1886.
Indo-Malayan Region (Banda).

43. **O. januarii**, Stp., MS.
1885. *Octopus januarii*, Hoyle, Diagnoses I., p. 229; Chall. Ceph., p. 97, pl. vii., figs. 1-4, 1886.
Pacific Ocean; West Indian Region.

44. **O. levis**, Hoyle, Diagnoses I., p. 229, 1885; Chall. Ceph., p. 98, pl. ii., figs. 1-4; pl. iii., fig. 1, 1886.

Stanford University Libraries

(Species insufficiently characterised.)

48. **O. brevipes**, d'Orb., Céph. acét., p. 61, pl. xvii., fig. 1, 1838.
Atlantic and Pacific (?) Oceans.

49. **O. capensis**, E. et S., Voy. "Bonite," p. 11, pl. i., figs. 6, 7, 1852.
South African Region.

50. **O. Ægina**, Gray, B.M.C., p. 7, 1849.
Hab. ?

51. **O. Cassiopea**, Gray, B.M.C., p. 9, 1849.
Mediterranean Region.

52. **O. Cephea**, Gray, B.M.C., p. 15, 1849.
Hab. ?

53. **O. Cyanea**, Gray, B.M.C., p. 15, 1849.
Australian Region.

54. **O. Eudora**, Gray, B.M.C., p. 9, 1849.
West Indian Region.

55. **O. favonia**, Gray, B.M.C., p. 9, 1849.
Indo-Malayan Region (Singapore).

56. **O. Geryonea**, Gray, B.M.C., p. 7, 1849.
West Indian Region (Brazil).

57. **O. medoria**, Gray, B.M.C., p. 14, 1849.
Hab. ?

58. **O. Berenice**, Gray, B.M.C., p. 11, 1849.
Hab. ?

59. **O. Saphenia**, Gray, B.M.C., p. 11, 1849.
Peruvian Region.

60. **O. Hardwickei**, Gray, B.M.C., p. 8, 1849.
Indo-Malayan Region (Singapore).

61. **O. pusillus**, Gld., Moll. Wilkes Exped., p. 478, fig. 591, 1852.
Indo-Malayan Region.

62. **O. mollis**, Gld., Moll. Wilkes Exped., p. 479, fig. 592, 1852.
Pacific Insular Region (Samoa).

63. **O. mimus**, Gld., Moll. Wilkes Exped., p. 473, fig. 587, 1852.
Peruvian Region.

64. **O. maorum**, Hutton, Manual N. Zeal. Moll., p. 1, 1880; Trans. N. Zeal. Inst., xiv., p. 162, pl. vi., fig. A. (*dentition*), 1882.
1885. *Octopus maorum*, Parker, Nature, xxxii., p. 586.
New Zealand Region.

65. **O. communis**, Park, Trans. N. Zeal. Inst., xvii., p. 198, 1885.
New Zealand Region.

66. **O. Harmandi**, de Rochebr., Bull. soc. philom. Paris [7], vi., p. 73, 1882.
Indo-Malayan Region.

67. **O. pilosus**, Risso, Hist. Nat. Eur. mérid., iv., p. 4, 1826.
Mediterranean Region.

68. **O. Peronii** (Lesr.), d'Orb.
1821. *Sepia Peronii*, Lesr., Journ. Acad. Nat. Sci. Philad., ii., p. 101.
1845. *Octopus Peronii*, d'Orb., Moll. viv., p. 185.
Australian Region.

69. **O. longipes**, Leach, Zool. Miscell., iii., p. 139, 1817.
Hab.?

70. **O. granosus**, Blv., Dict. d. Sci. Nat., xliii., p. 186, 1826.
Mediterranean Region.

71. **O. fimbriatus**, Rüppell, MS.
1838. *Octopus fimbriatus*, d'Orb., Céph. acét., p. 64.
Red Sea Region.

72. **O. fang-siao**, d'Orb., Céph. acét., p. 70, 1838.
Japanese Region.

73. **O. cærulescens**, Péron.
1826. *Octopus cærulescens*, Blv., Dict. d. Sci. Nat., xliii., p. 189.
Australian Region.

74. **O. didynamus**, Raf., Précis découv. somiol., p. 28, 1814.
Mediterranean Region.

75. **O. tetradynamus**, Raf., *loc. cit.*
Mediterranean Region.

Stanford University Libraries

Cistopus, Gray, 1849.

1. **C. indicus** (Rapp, MS.), Gray.[1]

1838. *Octopus indicus*, d'Orb., Céph. acét., p. 24, pl. xxv. ; pl. xxvi., figs. 1-4.
1849. *Cistopus* ,, Gray, B.M.C., p. 20.

South African and Indo-Malayan Regions.

Scæurgus, Troschel, 1857.

1. **S. titanotus**, Troschel, Archiv f. Naturgesch., xxiii., 1, p. 51, pl. iv., figs. 4, 5, 1857 ; *op. cit.*, xxiv., 1, p. 298, 1858.

Mediterranean Region.

2. **S. unicirrus** (d. Ch., MS.), Tiberi.[2]

1838. *Octopus unicirrhus*, d'Orb., Céph. acét., p. 70.
1851. ,, *Cocco*, Vér., Céph. médit., p. 22, pls. xii., xii. *bis*.
1857. *Scæurgus Coccoi*, Trosch., Archiv f. Naturgesch., xxiii., 1, p. 57, pl. iv., fig. 6.
1880. ,, *unicirrhus*, Tiberi, Bull. soc. mal. ital., vi., p. 12.

Mediterranean Region.

3. **S. tetracirrhus** (d. Ch., MS.), Tiberi.

1838. *Octopus tetracirrhus*, d'Orb., Céph. acét., p. 36, pl. xxii.
1851. ,, ,, Vér., Céph. médit., p. 25, pl. vii. *bis*, figs. 1, 2.
1880. *Scæurgus* ,, Tiberi, Bull. mal. ital., vi., p. 12.
1882. *Pteroctopus* ,, Fischer, Man. de Conch., p. 334.

Mediterranean Region.

Eledone, Leach, 1817.

Ozæna, Rafinesque.

1. **E. moschata** (Lmk.), Leach.

1799. *Octopus moschatus*, Lmk., Mém. Soc. Hist. Nat. Paris, i., p. 22, pl. ii.
1817. *Eledone moschata*, Leach, Zool. Miscell., iii., p. 138.
1838. ,, ,, d'Orb., Céph. acét., p. 72, pls. i., i. *bis*, iii.
1851. ,, *moschatus*, Vér., Céph. médit., p. 7, pls. iv.-vi.

Mediterranean Region.

[1] Just at the time of going to press, Professor Steenstrup writes me that it is, in his opinion, very doubtful whether d'Orbigny's two figures represent the same species. He is disposed to regard the type of Rapp's species as having been a true *Octopus*, and for the form with pouches between the arms he has adopted the name *Cistopus bursarius*.

[2] Vérany (*loc. cit.*, p. 24) admits that his *Octopus cocco* is identical with delle Chiaje's *Octopus unicirrhus*, and also recognises the priority of the latter, under which circumstances there can be no doubt that the name has been rightly restored by Dr Tiberi. D'Orbigny regarded it as a synonym of *Octopus vulgaris*.

2. **E. cirrosa** (Lmk.), d'Orb.[1]

1776. *Sepia octopodia* (*?*), Pennant, Brit. Zool., iv., p. 53, pl. xxviii., fig. 44.
1799. *Octopus cirrhosus*, Lmk., Mém. Soc. Hist. Nat. Paris, i., p. 21, pl. i., fig. 2.
1814. *Ozoena Aldrovandi*, Raf., Précis découv. somiol., p. 29.
1827. *Octopus ventricosus*, Grant, Edin. N. Phil. Journ., p. 309.
1838. *Eledone cirrhosus*, d'Orb., Céph. acét., p. 79, pl. ii.
1843. ,, *Pennantii*, Macgillivray, Moll. Anim. Scot., p. 31.
1843. ,, *Aldrovandi*, Macgillivray, *op. cit.*, p. 32.
1851. ,, ,, Vér., Céph. médit., p. 12, pls. ii., iii.
1851. ,, *Genei*, Vér., *op. cit.*, p. 15, pl. i.
1886. ,, *cirrosa*, Hoyle, Chall. Ceph., p. 102.

Scandinavian, Lusitanian, and Mediterranean Regions.

3. **E. verrucosa**, Vll., "Blake" Rep., p. 105, pls. v., vi., 1881; Ceph. N. E. Amer., p. 380, pls. lii., liii., 1881.

1886. *Eledone verrucosa*, Hoyle, Chall. Ceph., p. 104.

Atlantic and Pacific Oceans; New England Region.

4. **E. rotunda**, Hoyle, Diagnoses I., p. 230, 1885; Chall. Ceph., p. 104, pl. viii., figs. 4-6, 1886.

Pacific and Southern Oceans.

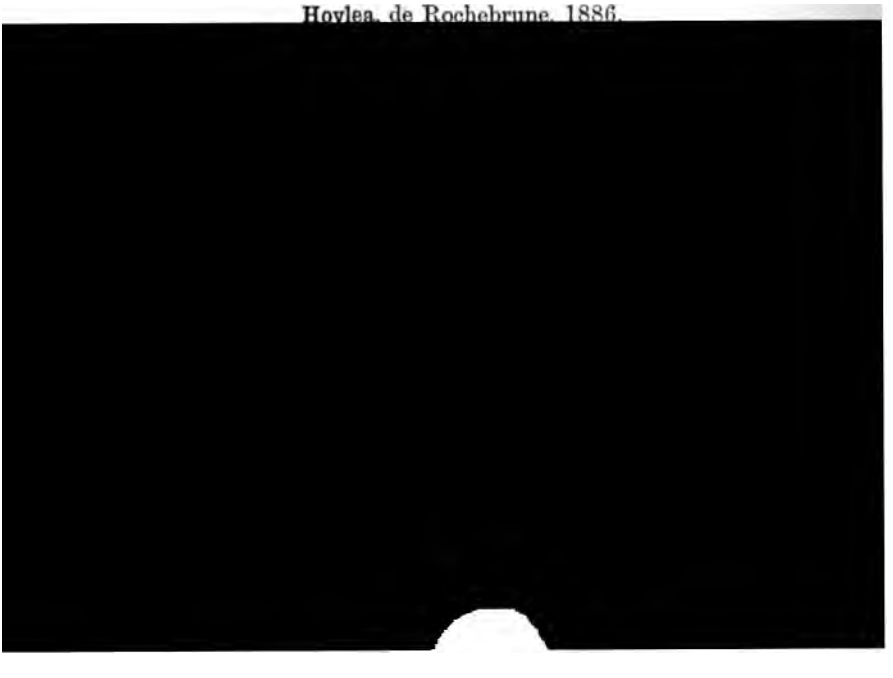
5. **E. brevis**, Hoyle, Diagnoses I., p. 230, 1885; Chall. Ceph., p. 105, pl. viii., fig. 7, 1886.

Atlantic Ocean.

6. **E. Halliana**, Rochebr., Monogr. Eledonidæ, p. 162, 1884.

Lusitanian Region.

Hoylea, de Rochebrune, 1886.



Stanford University Libraries

1884. *Hallia sepioidea*, Rochebr., Monogr. Eledonidæ, p. 156, pl. vii.
1886. *Hoylea* ,, Rochebr., Bull. soc. philom. Paris [7], ix., p. 85.
Lusitanian Region.

Eledonenta, de Rochebrune, 1884.

1. **E. Filholiana**, Rochebr., Monogr. Eledonidæ, p. 157, 1884.
Pacific Insular Region (Fiji Islands).
2. **E. microsicya**, de Rochebr., Monogr. Eledonidæ, p. 158, 1884.
Red Sea Region.

Eledonella, Verrill, 1884.

Japetella, Hoyle (*pars*).

1. **E. pygmæa**, Vll., Second Catal., p. 145, pl. xxxii., fig. 2, 1884.
Atlantic Ocean.
2. **E. diaphana**, Hoyle.
1885. *Japetella diaphana*, Hoyle, Diagnoses I., p. 232.
1886. *Eledonella* ,, Hoyle, Chall. Ceph., p. 107, pl. ix., figs. 3-6.
Pacific Ocean.

Japetella, Hoyle, 1885.

1. **J. prismatica**, Hoyle, Diagnoses I., p. 231, 1885; Chall. Ceph., p. 109, pl. ix., figs. 1, 2, 1886.
Atlantic Ocean.

Bolitæna, Steenstrup, 1859.

1. **B. microcotyla**, Stp., MS.[1]
1859. *Bolitæna* sp., Stp., Vid. Meddel. nat. Foren. Kjöbenhavn, 1858, p. 183.
Atlantic Ocean.

Suborder II. DECAPODA, Leach, 1818.

Division I. Myopsida, d'Orbigny, 1845.

Family VII. Sepiolini, Steenstrup, 1861.

Sepiola (Rondelet, 1554), Leach, 1817.

1. **S. Rondeleti**, Leach.

[1] *Bolitæna microcotyla* has a soft ovoid body of gelatinous consistency, and a reddish-purple colour, somewhat resembling *Cirroteuthis*, but destitute of fins, and with the mantle-opening very wide, extending beyond the eyes instead of being a narrow aperture immediately surrounding the funnel. The arms are comparatively short and slender, webbed almost up to the extremities, and provided with a single row of very small suckers. The jaws are very little curved, and the radula is remarkable in that the rows of teeth present a serial repetition, the fifth resembling the first.

1558. *Sepiola Rondeleti*, Gesner, De Aquat., iv., p. 855.
1817. ,, *Rondeletii*, Leach, Zool. Miscell., iii., p. 140.
1839. ,, ,, d'Orb., Céph. acét., p. 230, pl. i., figs. 1-6; pl. ii., figs. 3-13; pl. iii., figs. 6-9.
1845. ,, *oceanica*, d'Orb., Moll. viv., pl. x., fig. 13 (*err.*).
1869. ,, *major* (?), Targ., Cef. Mus. Firenze, p. 45.
1886. ,, *rondeleti*, Hoyle, Chall. Ceph., p. 110.

Scandinavian, Lusitanian, Mediterranean, and West African Regions.

2. **S. Oweniana**, d'Orb.

1839. *Sepiola Oweniana*, d'Orb., Céph. acét., p. 229, pl. iii., figs. 1-5.
1867. ,, ,, (?) Mörch, Vid. Meddel. nat. Foren. Kjöbenhavn, p. 101.
1879. ,, ,, (?) Tryon, Man. Conch., vol. i., p. 156 (*habitat*).

Hab. ?

3. **S. pacifica**, Kirk, Trans. N. Zeal. Inst., xiv., p. 283, 1882.
New Zealand Region.

4. **S. atlantica**, d'Orb., Céph. acét., p. 235, pl. iv., figs. 1-12, 1839.
Lusitanian Region.

5. **S. stenodactyla**, Grant, Trans. Zool. Soc. Lond., i., p. 84, pl. ii., figs. 1, 2, 1833.
South African Region (Mauritius).

6. **S. pusilla**, Pffr.,[1] Ceph. Hamb. Mus., p. 7, fig. 9, 1884.
Atlantic Ocean.

Stanford University Libraries

Inioteuthis, Verrill, 1881.

1. **I. japonica** (Tilesius, MS.), Vll.
   1839. *Sepiola Japonica*, d'Orb., Céph. acét., p. 234.
   1881. *Inioteuthis* ,, Vll., Ceph. N. E. Amer., p. 417.
   Japanese Region.
2. **I. Morsei**, Vll.
   1881. *Inioteuthis Morsei*, Vll., Ceph. N. E. Amer., p. 417.
   1884. *Sepiola bursa* (?), Pffr., Ceph. Hamb. Mus., p. 6, fig. 6.
   1886. *Inioteuthis Morsei*, App., Japanska Ceph., p. 15, pl. ii., figs. 15, 16; pl. iii., figs. 16, 19, 20, 23.
   1886. ,, ,, Hoyle, Chall. Ceph., p. 112, pl. xiv., figs. 1-9.
   Japanese Region.

Stoloteuthis, Verrill, 1881.

1. **S. leucoptera**, Vll.
   1878. *Sepiola leucoptera*, Vll., Amer. Journ. Sci., xvi., p. 378.
   1881. *Stoloteuthis* ,, Vll., Ceph. N. E. Amer., pp. 347, 418, pl. xxxi., figs. 4, 5; pl. liv., fig. 4.
   New England Region.

Nectoteuthis, Verrill, 1883.

1. **N. Pourtalesii**, Vll., "Blake" Suppl., p. 108, pl. iii., fig. 1, 1883.
   West Indian Region.

Rossia, Owen, 1834.

Heteroteuthis, Vll.

1. **R. palpebrosa**, Owen, Ross's Second Arctic Voy., Nat. Hist., p. 93, pl. B, fig. 1; pl. C, 1834.
   Arctic Region.
2. **R. macrosoma** (d. Ch.), d'Orb.
   1829. *Sepiola macrosoma*, d. Ch., Mem. stor. anim., t. lxxi. (*fide* Gerv. et v. Ben.).
   1839. ,, ,, Gerv. et v. Ben., Bull. Acad. Sci. Bruxelles, vi., p. 39.
   1839. *Rossia* ,, d'Orb., Céph. acét., p. 245, pl. iv., figs. 13-24.
   1869. ,, *Panceri*, Targ., Ceph. Mus. Firenze, p. 46, pl. vii., fig. 7 (♂).
   Scandinavian, Mediterranean, and Arctic Regions.
3. **R. Oweni**, Ball, Proc. Roy. Irish Acad., ii., p. 193 (♂).[1]

[1] There can be little doubt that, as Steenstrup has suggested (Hectocotyl., p. 15), the two forms described by Ball are of different sexes and not of different species, although it is not true, as stated by Jeffreys (Brit. Conch., v., p. 134), that he "considers *R. Owenii* of Ball the male, and his *R. Jacobii* the female, of *R. macrosoma*." The distinguishing characters indicated by

1842. *Rossia Jacobi*, Ball, Proc. Roy. Irish Acad., ii., p. 193 (♀).
1845. ,, *Owenii*, Lovén, Öfversigt k. Vetensk.-Akad. Förhandl., p. 121.
1853. ,, ,, Forbes and Hanley, Brit. Moll., iv., p. 223, pl. sss, fig. 1.
1886. ,, *oweni*, Hoyle, Chall. Ceph., p. 114; pl. xv., figs. 1-9.
Scandinavian Region.

4. **R. glaucopis**, Lovén, Öfversigt k. Vetensk.-Akad. Förhandl., p. 121, 1845.
1869. *Rossia papillifera*, Jeffreys, Brit. Conch., v., p. 134.[1]
1878. ,, *glaucopis*, Sars, Moll. Reg. Arct. Norv., p. 337, pl. xxxii.
1886. ,, ,, Hoyle, Chall. Ceph., p. 116.
Scandinavian and Arctic Regions.

5. **R. Hyatti**, Vll., Amer. Journ. Sci., xvi., p. 208, 1878; Ceph. N. E. Amer., p. 351, pl. xxvii., figs. 8, 9; pl. xxx., fig. 1; pl. xxxi., figs. 1, 2; pl. xlvi., fig. 5, 1881.
New England Region.

6. **R. sublevis**, Vll.
1878. *Rossia sublævis*, Vll., Amer. Journ. Sci., xvi., p. 209.
1881. ,, *sublevis*, Vll., Ceph. N. E. Amer., pp. 354, 419, pl. xxx., fig. 2; pl. xxxi., fig. 3; pl. xlvi., fig. 4; pl. xlvii., figs. 2-4.
1886. ,, ,, Hoyle, Chall. Ceph., p. 117.
New England and Patagonian Regions.

7. **R. brachyura**, Vll., "Blake" Suppl., p. 110, pl. iii., fig. 2, 1883.
West Indian Region.

8. R. Mölleri, Stp., Hectocotyl., p. 198, pl. ii., fig. 1, 1856.

Stanford University Libraries

11. **R. megaptera**, Vll., Ceph. N. E. Amer., p. 349, pl. xxxviii., fig. 1; pl. xlvi., fig. 6, 1881.
Atlantic Ocean; New England Region.

Heteroteuthis, Gray, 1849 (*non* Verrill).
Rossia, Vérany et Auctt. (*pars*).

1. **H. dispar** (Rüppell), Gray.
1845. *Sepiola dispar*, Rüpp., Giorn. Gab. Messina, t. xxvi. (*fide* Vér.).
1849. *Rossia* (*Heteroteuthis*) *dispar*, Gray, B.M.C., p. 90.
1851. ,, *dispar*, Vér., Céph. médit., p. 63, pl. xxiii., figs. *d-h*.
1857. ,, ,, Trosch., Archiv f. Naturgesch., xxiii., 1, p. 62, pl. iv., figs. 7, 8.
1858. ,, ,, Claus, *op. cit.*, xxiv., 1, p. 259, Taf. x, fig. 5.
Mediterranean Region.

Promachoteuthis, Hoyle, 1885.

1. **P. megaptera**, Hoyle, Narr. Chall. Exp., i., p. 273, fig. 109, 1885; Chall. Ceph., p. 120, pl. xiv., figs. 10-14, 1886.
Pacific Ocean.

Family VIII. Sepiarii, Steenstrup, 1861.
Sepidæ, d'Orb. (*pars*).

Subfamily, Sepiadarii, Steenstrup, 1881.

Sepioloidea, d'Orbigny, 1839.

1. **S. lineolata** (Q. et G.), d'Orb.
1832. *Sepiola lineolata*, Q. et G., Voy. "Astrolabe," ii., p. 82, pl. v., figs. 8-13.
1839. *Sepioloidea lineata*, d'Orb., Céph. acét., p. 240, pl. iii., figs. 10-18.
1881. ,, ,, Stp., Sep. og Idiosep., p. 233.
1884. ,, ,, Brock, Zeitschr. f. wiss. Zool., xl., pp. 105-120.
Australian Region.

Sepiadarium, Steenstrup, 1881.

1. **S. Kochii**, Stp., Sep. og Idiosep., p. 214, pl. i., figs. 1-10.
Indian Ocean.

Subfamily Idiosepii, Steenstrup, 1881.[1]

Idiosepius, Steenstrup, 1881.

1. **I. pygmæus**, Stp., Sep. og Idiosep., p. 219, pl. i., figs. 11-22, 1881.
Indian Ocean; Indo-Malayan Region.

[1] Steenstrup (*op. cit.*, p. 224) suggests the possibility that *Cranchia minima*, Fér., and *Loligopsis peronii*, Lmk., may be allied to this form.

Spirula, Lamarck, 1801.[1]

1. **S. Peronii**, Lmk., Anim. s. vert., vii., p. 601, 1822.
   1879. *Spirula Peronii*, Agassiz, Bull. Mus. Comp. Zoöl., v., p. 298.
   1865. *Ammonia lævis*, Angas, Proc. Zool. Soc. Lond., p. 157.
   1886. *Spirula peronii*, Hoyle, Chall. Ceph., p. 122.
   West Indian, Indo-Malayan, and Australian Regions.[2]

Subfamily Eusepii, Steenstrup, 1881.

Sepia, Linné, 1766.

Rhombosepion, *Lophosepion*, *Spathidosepion*, *Doratosepion*, *Ascarosepion*, *Acanthosepion*, } de Rochebrune.[3]

1. **S. officinalis**, Linn., Fauna Suecica, No. 2106, 1761.
   1839. *Sepia officinalis*, d'Orb., Céph. acét., p. 260, pl. i.; pl. ii., figs. 4, 5; pl. iii., figs. 1-3; pl. xvii., figs. 1, 2.
   Scandinavian, Lusitanian, Mediterranean, and West African Regions.
2. **S. Filliouxii**, Lafont.
   1839. *Sepia officinalis*, d'Orb., Céph. acét., pl. ii., figs. 1, 2, 3.
   1851. ,, ,, Vér., Céph. médit., pl. xxv.
   1868. ,, *Filliouxii*, Lafont, Bull. Assoc. Sci. Franc., No. 81 (*fide* Laf.).
   1869. ,, ,, Lafont, Journ. de Conch. [3], ix., p. 11.
   Lusitanian and Mediterranean Regions.
3. **S. myrsus**, Gray, B.M.C., p. 108, 1849.
   Indo-Malayan Region.

Stanford University Libraries

1839. *Sepia Hierredda*, d'Orb., Céph. acét., p. 268, pls. xiii., xviii.
1875. ,, *hieredda*, Stp., Hemisep., p. 478, pl. ii., fig. 2.
West and South African Regions.

6. **S. Vicellius**, Gray, B.M.C., p. 100, 1849.
Hab. ?

7. **S. Savignyi**, Blv., Dict. Sci. Nat., xlviii., p. 285, 1827.
1827. *Sepia officinalis*, Aud., Expl. pl. Hist. Nat. Egypte, pl. v. ; pl. i., fig. 3 (*fide* d'Orb.).
1839. ,, *Savignyi*, d'Orb., Céph. acét., p. 268, pls. xiii., xviii.
Red Sea Region.

8. **S. Smithi**, Hoyle, Diagnoses II., p. 190, 1885 ; Chall. Ceph., p. 124, pl. xvi., figs. 1-12, 1886.
Indo-Malayan Region.

9. **S. papuensis**, Hoyle, Diagnoses II., p. 197, 1885 ; Chall. Ceph., p. 126, pl. xvi., figs. 13-23, 1886.
Indo-Malayan Region.

10. **S. Pagenstecheri**, Pffr., Ceph. Hamb. Mus., p. 9, fig. 12, 1884.
Indo-Malayan Region.

11. **S. plangon**, Gray,[1] B.M.C., p. 104, 1849.
1886. *Sepia plangon*, Hoyle, Chall. Ceph., p. 128.
Australian Region.

12. **S. singaporensis**,[1] Pffr., Ceph. Hamb. Mus., p. 10, fig. 13, 1884.
Indo-Malayan Region.

13. **S. polynesica**, Pffr., *op. cit.*, p. 11, fig. 14, 1884.
Pacific Insular Region.

14. **S. Bertheloti**, d'Orb., Moll. Canaries, p. 21, 1839 ; Céph. acét., p. 214, pls. xi., xxiii., 1839.
West African Region.

15. **S. Verreauxi** (Rochebr.).
1884. *Ascarosepion Verreauxi*, Rochebr., Monogr. Sepiadæ, p. 98.
Australian Region.

16. **S. vermiculata**, Q. et G., Voy. "Astrolabe," ii., p. 64, pl. i., figs. 1-5, 1832.
1839. *Sepia vermiculata*, d'Orb., Céph. acét., p. 279, pl. iii. *bis*.
South African Region.

17. **S. latimanus**, Q. et G., Voy. "Astrolabe," ii., p. 68, pl. ii., figs. 2-11, 1832.
1839. *Sepia latimanus*, d'Orb., Céph. acét., p. 283, pl. xii., figs. 1-6 ; pl. xvii., figs. 16, 17.
Indo-Malayan and Australian Regions.

[1] It is quite possible that these two species are identical.

18. **S. esculenta**, Hoyle, Diagnoses II., p. 188, 1885; Chall. Ceph., p. 129, pl. xvii., figs. 1-5; pl. xviii., figs. 1-6, 1886.
    Japanese Region.
19. **S. aculeata**, van Hasselt, MS.
    1839. *Sepia aculeata*, d'Orb., Céph. acét., p. 287, pl. v. *bis*; pl. xxv.
    1875. ,, ,, Stp., Hemisep., pl. ii., fig. 4.
    1884. *Acanthosepion Hasselti*, Rochebr., Monogr. Sepiadæ, p. 101.
    Indo-Malayan Region.
20. **S. indica**, d'Orb., Céph. acét., p. 288, pl. xxi., 1839.[1]
    Indo-Malayan Region.
21. **S. zanzibarica**, Pffr., Ceph. Hamb. Mus., p. 9, fig. 11, 1884.
    South African Region.
22. **S. rostrata**, d'Orb., Céph. acét., p. 284, pl. viii., fig. 6; pl. xxvi., 1839.
    1884. *Acanthosepion spinigerum*, Rochebr., Monogr. Sepiadæ, p. 103.
    Indo-Malayan and Australian Regions.
23. **S. Rouxii**, d'Orb.
    1831. *Sepia Pharaonis* (?), Ehrbg., Symb. Phys., An. Moll. Ceph., Sep. No. 1.
    1839. ,, *Rouxii*, d'Orb., Céph. acét., p. 271, pl. xix.
    Red Sea and Indo-Malayan Regions.
24. **S. elliptica**, Hoyle, Diagnoses II., p. 189, 1885; Chall. Ceph., p. 131, pl. xix., figs. 14-24, 1886.
    Indo-Malayan Region.
25. **S. brevimana**, Stp., Hemisep., pp. 475, 479, 1875.

Stanford University Libraries

1884. *Doratosepion trygoninum*, Rochebr., Monogr. Sepiadæ, p. 97.
Red Sea Region.

32. **S. recurvirostra**, Stp., Hemisep., pp. 475, 479, 1875.
1886. *Sepia recurvirostra*, Hoyle, Chall. Ceph., p. 137.
Indo-Malayan Region.

33. **S. sulcata**, Hoyle, Diagnoses II., p. 192, 1885; Chall. Ceph., p. 137, pl. xix., figs. 1-13, 1886.
Indo-Malayan Region.

34. **S. Andreana**, Stp., Hemisep., pp. 474, 479, pl. i., figs. 11-19, 1875.
Japanese Region.

35. **S. andreanoides**, Hoyle, Diagnoses II., p. 193, 1885; Chall. Ceph., p. 139, pl. xxi., figs. 11-19; pl. xxii., fig. 11, 1886.
Japanese region.

36. **S. Peterseni**, App., Japanska Ceph., p. 23, pl. ii., figs. 1-6; pl. iii., fig. 21, 1886.
Japanese Region.

37. **S. kiensis**, Hoyle, Diagnoses II., p. 194, 1885; Chall. Ceph., p. 141, pl. xvii., figs. 6-11, 1886.
Indo-Malayan Region.

38. **S. kobiensis**, Hoyle, Diagnoses II., p. 195, 1885; Chall. Ceph., p. 142, pl. xviii., figs. 7-14, 1886.
Japanese Region.

39. **S. capensis**, d'Orb., Céph. acét., pl. vii., figs. 1-3, 1826.
1832. *Sepia australis*, Q. et G., Voy. "Astrolabe," ii., p. 70, pl. v., figs. 3, 7.
1839. ,, *capensis*, d'Orb., Céph. acét., p. 278, pl. vii., figs. 1-3; pl. xii., figs. 7-11; pl. xvii., figs. 18, 19.
1849. ,, *Sinope* (?), Gray, B.M.C., p. 106.
South African Region.

40. **S. elongata**, d'Orb., Céph. acét., p. 283, pl. xxiv., figs. 7-10, 1839.
Red Sea Region.

41. **S. elegans**, d'Orb., Céph. acét., p. 280, pl. viii., figs. 1-5; pl. xxvii., figs. 3-6, 1829.
Mediterranean Region.

42. **S. Ruppellaria**, d'Orb.
1839. *Sepia Rupellaria*, d'Orb., Céph. acét., p. 275, pl. iii., figs. 10-13.
1851. ,, *bisserialis*, Vér., Céph. médit., p. 73, pl. xxvi., figs. F, K.
1869. ,, *rupellaria*, Fischer, Actes Linn. Soc. Bordeaux, xxvii., p. 125.
Lusitanian and Mediterranean Regions.

43. **S. Lefebrei**, d'Orb., Céph. acét., p. 282, pl. **xxiv.**, **figs. 1-6, 1839.**
Red Sea Region.

44. **S. palmata**, Owen, Trans. Zool. Soc. Lond., **xi., 5, p. 134,** pls. xxiv., xxv., 1881.
Australian Region.

45. **S. apama**, Gray, B.M.C., p. 103, 1849.
Australian and New Zealand Regions.

46. **S. tuberculata**, Lmk., Mém. Soc. Hist. Nat. Paris, i., p. 9, pl. i., fig. 1, 1799.
1832. *Sepia papillata*, Q. et G., Voy. "Astrolabe," ii., p. 61, pl. i., figs. 6-14.
1875. ,, *tuberculata*, Stp., Hemisep., pp. 474, 479, pl. i., figs. 20, 21 ; pl. ii., fig. 6.
South African Region.

Subgenus **Metasepia**, Hoyle 1885.

47. **S. Pfefferi**, Hoyle.
1885. *Sepia* (*Metasepia*) *Pfefferi*, Hoyle, Diagnoses II., p. 199 ; Chall. Ceph., p. 145, pl. xxi., figs. 1-10, 1886.
Indo-Malayan Region.

48. **S. Tullbergi**, App., Japanska Ceph., p. 26, pl. ii., figs. 7-14, 1886.
Japanese Region.

(Species insufficiently characterised.)

49. S. gibbosa, Flurbg., Syreb. rhus., Anim. Moll. Ceph., Sep.

Stanford University Libraries

55. **S. goreensis** (Rochebr.).
    1884. *Acanthosepion Goreense*, Rochebr., Monogr. Sepiadæ, p. 109.
    West African Region.

56. **S. enoplon** (Rochebr.).
    1884. *Acanthosepion enoplon*, Rochebr., Monogr. Sepiadæ, p. 108.
    Mediterranean Region.

57. **S. oculifera** (Rochebr.).
    1884. *Acanthosepion oculiferum*, Rochebr., Monogr. Sepiadæ, p. 107.
    West African Region.

58. **S. antillarum**, d'Orb., Moll. Cuba, i., p. 33, 1838.
    1845. *Sepia antillarum*, d'Orb., Moll. viv., p. 300.
    West Indian Region.

Sepiella, Gray, 1849; Steenstrup, 1880.

Sepia, Auctt. (*pars*).

1. **S. inermis** (van Hasselt, MS.), Stp.
    1839. *Sepia inermis*, d'Orb., Céph. acét., p. 286, pl. vi. *bis* (=♂); pl. xx., figs. 1-9 (=♀).
    1839. ,, *sinensis*, d'Orb., Céph. acét., p. 289, pl. ix., figs. 1, 2 (*fide* Gray).
    1849. ,, *microcheirus*, Gray, B.M.C., p. 107.
    1875. ,, *inermis*, Stp., Hemisep., p. 478, pl. ii., fig. 3.
    1880. *Sepiella* ,, Stp., Sepiella, pp. 347-356, figs. 1-8.
    Indo-Malayan Region.

2. **S. ornata** (Rang), Stp.
    1837. *Sepia ornata*, Rang, Mag. Zool., ann. vii., cl. v., p. 76, pl. ci.
    1839. ,, ,, d'Orb., Céph. acét., p. 276, pl. xxii.
    1849. ,, ,, Gray, B.M.C., p. 106.
    1880. *Sepiella* ,, Stp., Sepiella, pp. 347-356.
    West African Region.

3. **S. curta**, Pffr., Ceph. Hamb. Mus., p. 13, fig. 16, 1884.
    Indo-Malayan Region.

4. **S. ocellata**, Pffr., *op. cit.*, p. 13, fig. 17.
    Indo-Malayan Region.

5. **S. ovata**, Pffr., *op. cit.*, p. 14, fig. 18.
    Hab. ?

6. **S. obtusata**, Pffr., *op. cit.*, p. 15, fig. 19.
    Hab. ?

7. **S. tourrannensis** (E. et S.), Voy. "Bonite," p. 33, pl. iii., figs. 6-12, 1852.
    Indo-Malayan Region.

8. **S. affinis** (E. et S.), *op. cit.*, p. 35, pl. iii., figs. 13, 14.
    Hab. ?

9. **S. Maindroni**, Rochebr., Monogr. Sepiadæ, p. 89, 1884.
   1886. *Sepiella Maindroni*, Hoyle, Chall. Ceph., p. 149, pl. xxii., figs. 1-10.
   Indo-Malayan and Japanese Regions.
10. **S. (?) Dabryi** (Rochebr.).
   1884. *Diphtherosepion Dabryi*, Rochebr., Monogr. Sepiadæ, p. 81.
   Indo-Malayan Region.
11. **S. (?) Martini** (Rochebr.).
   1884. *Diphtherosepion Martini*, Rochebr., Monogr. Sepiadæ, p. 81.
   Indo-Malayan Region.

Hemisepius, Steenstrup, 1875.

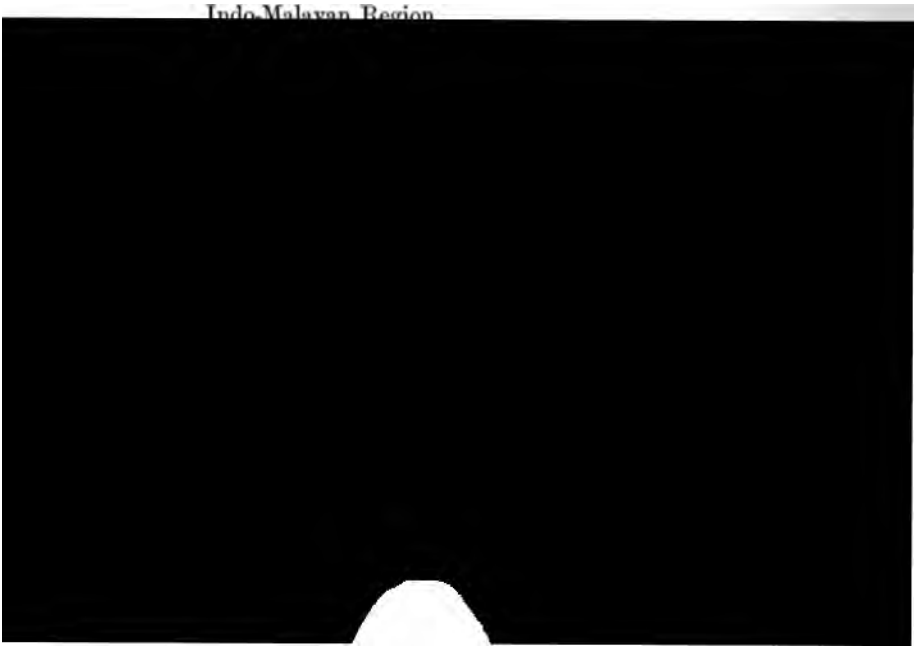
1. **H. typicus**, Stp., Hemisep., pp. 465-479, pl. i., figs. 1-10; pl. ii., fig. 1, 1875.
   South African Region.

Family IX. LOLIGINEI, Steenstrup, 1861.

Sepioteuthis, Blainville, 1825.

Chondrosepia, Leuckart.

1. **S. sepioidea** (Blv.), d'Orb.
   1823. *Loligo sepioidea*, Blv., Journ. de Phys., xcvi., p. 123.
   1839. *Sepioteuthis sepioidea*, d'Orb., Céph. acét., p. 298, pl. vii.
   1875. ,, ,, Stp., Hemisep., p. 478, pl. ii., figs. 7, 8.
   West Indian Region.
2. **S. Blainvilliana**, Fér., d'Orb., Céph. acét., p. 303, pl. ii., 1839.
   Indo-Malayan Region.



Stanford University Libraries

1839. *Sepioteuthis lunulata*, d'Orb., Céph. acét., p. 300, pl. iii., fig. 1 ; pl. vi., figs. 1-8.

Australian and Pacific Insular Regions.

7. **S. ovata**, Gabb, Amer. Journ. Conch., iv., p. 193, pl. xvii., 1868.
West Indian Region.

8. **S. Sloanii**, Leach, MS. ; Gray, B.M.C., p. 81, 1849.
West Indian Region.

9. **S. bilineata** (Q. et G.), d'Orb.
1832. *Sepia bilineata*, Q. et G., Voy. "Astrolabe," ii., p. 66, pl. ii., fig. 1.
1839. *Sepioteuthis bilineata*, d'Orb., Céph. acét., p. 301, pl. iv., fig. 2.
New Zealand Region.

10. **S. neoguinaica**, Pffr., Ceph. Hamb. Mus., p. 4, fig. 2, 1884.
Indo-Malayan Region.

11. **S. Lessoniana**, Fér., d'Orb., Tabl. méth., Ann. d. Sci. Nat., t. vii., p. 155, 1826.
1830. *Sepioteuthis Lessoniana*, Lesson, Voy. "Coquille," Moll., p. 241, pl. xi.
1839. ,, ,, d'Orb., Céph. acét., p. 302, pls. i. ; vi., figs. 9-14.
1886. ,, ,, Hoyle, Chall. Ceph., p. 151.
Indo-Malayan, Japanese, New Zealand, and Pacific Insular Regions.

12. **S. loliginiformis** (Lkt.), d'Orb.
1828. *Chondrosepia loliginiformis*, Lkt., Atlas Reise im nördl. Afrika, Wirbell. Th., p. 21, pl. vi., fig. 1.
1831. *Sepioteuthis Hemprichii* (?), Ehrbg., Symb. Phys., Anim. Moll. Ceph.
1839. ,, *loliginiformis*, d'Orb., Céph. acét., p. 299, pl. iv., fig. 1.
Red Sea Region.

(Species insufficiently characterised.)

13. **S. major**, Gray,[1] Spicil. Zool., p. 3, pl. iv., fig. 1, 1828 ; B.M.C., p. 83, 1849.
South African Region.

14. **S. madagascariensis**, Gray, B.M.C., p. 80, 1849.
South African Region.

15. **S. brevis**, Owen, Trans. Zool. Soc. Lond., xi., 5, p. 137, pl. xxvi., fig. 1, 1881.
Japanese Region.

16. **S. sinensis**, d'Orb., Céph. acét., p. 304, 1839.
Japanese Region.

[1] The figure is very suggestive of *Thysanoteuthis rhombus*, Troschel, with which Gray's remark, "the giant of the genus," would also agree.

17. **S. arctipinnis**, Gld., Moll. Wilkes Exped., p. 479, fig. 593, 1852.

Pacific Insular Region (Sandwich Islands).

Loligo, Lamarck, 1799.[1]

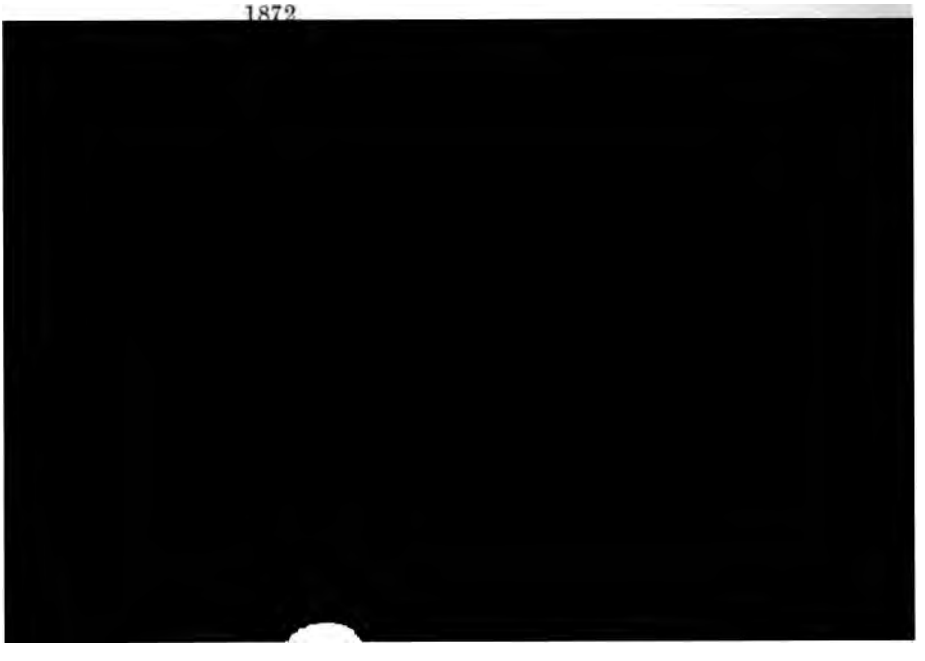
1. **L. vulgaris**, Lmk., Mém. Soc. Hist. Nat. Paris, i., p. 11, 1799.
   - 1823. *Loligo pulchra*, Blv., Dict. Sci. Nat., xxvii., p. 144.
   - 1833. ,, *Rangii*, Fér., Céph. acét., pl. xix., figs. 4-6.
   - 1839. ,, *vulgaris*, d'Orb., Céph. acét., p. 308, pls. viii.-x., xxii.; xxiii., figs. 1-12.
   - 1849. ,, *neglecta*, Gray, B.M.C., p. 72.
   - 1851. ,, *Berthelotii* (?), Vér., Céph. médit., p. 93, pl. xxxvi., figs. h-k.
   - 1869. ,, *mediterranea*, Targ., Cef. Mus. Firenze, p. 86.
   - 1869. ,, *pulchra*, Fischer, Journ. de Conch. [3], ix., p. 129.

   Scandinavian, Lusitanian, and Mediterranean Regions.
2. **L. affinis**, Lafont,[2] Actes Linn. Soc. Bordeaux, xxviii., p. 273, pl. xiii., 1872; Journ. de Conch. [3], xii., p. 22, 1872.

   Lusitanian Region.
3. **L. macrophthalma**, Lafont, *opp. citt.*, p. 274, pl. xv., 1871; [3], xii., p. 23, 1872.

   Lusitanian Region.
4. **L. microcephala**, Lafont, *opp. citt.*, p. 273, pl. xiv., 1871; [3], xii., p. 22, 1872.

   Lusitanian Region.
5. **L. Moulinsi**, Lafont, *opp. citt.*, p. 274, 1871; [3], xii., p. 23, 1872.



Stanford University Libraries

1873. *Loligo brevipes*, Mörch, Nachrichtsbl. malak. Gesellsch., No. 5 (*err. typ.*) (*fide* Lenz).
1875. ,, *breviceps*, Lenz, Jahresb. Comm. Kiel, Anhang, p. 23, pl. i., figs. 5, 6 ; pl. ii., figs. 1-9 (pub. 1878).

Scandinavian Region.

7. **L. Forbesii**, Stp., Hectocotyl., p. 189, pl. i., fig. 2, 1856.
1858. *Loligo magna*, Adams, Gen. Rec. Moll., pl. iv., fig. 3.
1871. ,, *Forbesii*, Lenz, Jahresb. Comm. Kiel, Jahrg. i., p. 135.
1885. ,, ,, Hoyle, Proc. Roy. Phys. Soc. Edin., viii., p. 459.

Scandinavian and Lusitanian Regions.

8. **L. Pealei**, Lesr., Journ. Acad. Nat. Sci. Philad., ii., p. 92, 1821.
1843. *Loligo punctata*, de Kay, Moll. New York, p. 3, pl. i., fig. 1.
1881. ,, *Pealei*, Vll., Ceph. N. E. Amer., p. 308, pl. xxix., figs. 1-4 ; pl. xxxvii., figs. 1-3 ; pl. xxxix., fig. 4 ; pls. xl., xli. ; pl. xlv., figs. 3, 4.

New England Region.

9. **L. edulis**, Hoyle, Diagnoses II., p. 186, 1885 ; Chall. Ceph., p. 152, pl. xxiii., 1886.

Japanese Region.

10. **L. patagonica**, E. A. Sm., Proc. Zool. Soc., p. 24, pl. iii., fig. 2, 1881.

Patagonian Region.

11. **L. brasiliensis**, Blv., Journ. de Phys., xcvi., p. 132, 1823.
1839. *Loligo brasiliensis*, d'Orb., Céph. acét., p. 313, pl. xii. ; pl. xix., fig. 1 ; pl. xx., figs. 1-5.
1886. ,, ,, Hoyle, Chall. Ceph., p. 153.

West Indian Region.

12. **L. gahi**, d'Orb., Amér. mérid., p. 60, pl. iii., figs. 1, 2, 1835 ; Céph. acét., p. 316, pl. xxi., figs. 3, 4, 1839.

West Indian, Peruvian, and Patagonian Regions.

13. **L. kobiensis**, Hoyle, Diagnoses II., p. 184, 1885 ; Chall. Ceph., p. 154, pl. xxv., figs. 1-10, 1886.

Japanese Region.

14. **L. Pfefferi**, Hoyle.
1884. *Loligo brevipinnis*, Pffr., Ceph. Hamb. Mus., p. 5, fig. 4.
1886. ,, *pfefferi*, Hoyle, Chall. Ceph., p. 29.

Pacific Insular Region.

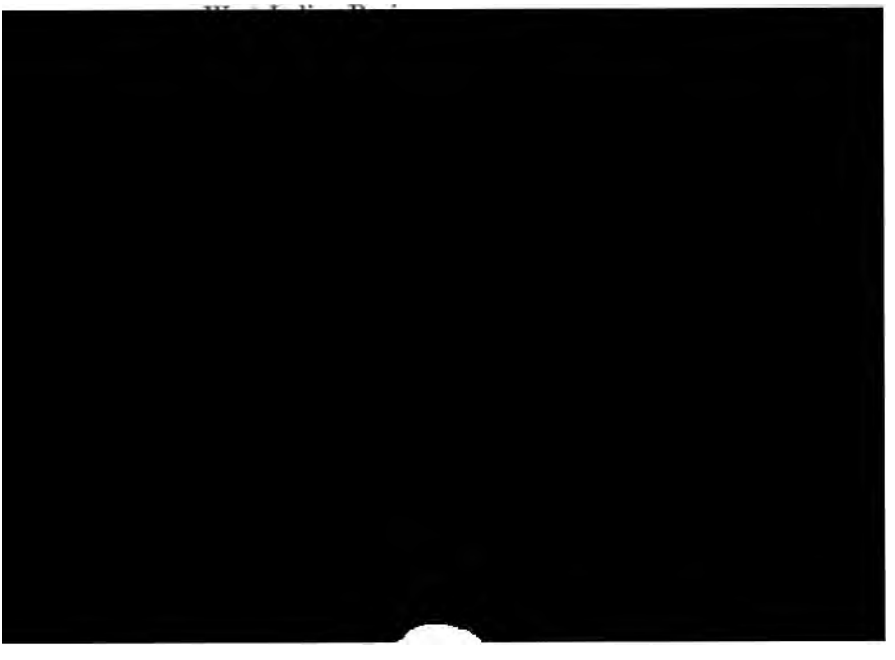
15. **L. sumatrensis**, d'Orb., Céph. acét., p. 317, pl. xiii., figs. 1-3, 1839.

Indo-Malayan Region.

16. **L. spectrum**, Pffr., Ceph. Hamb. Mus., p. 5, fig. 5, 1884.

Pacific Insular Region.

17. **L. Duvaucelii**, d'Orb., Céph. acét., p. 318, pls. xiv.; xx., figs. 6-16, 1839.
    Indo-Malayan Region.
18. **L. indica**, Pffr., Ceph. Hamb. Mus., p. 4, fig. 3.
    1886. *Loligo indica*, Hoyle, Chall. Ceph., p. 156, pl. xxvi.
    Indo-Malayan Region.
19. **L. Bleekeri**, Keferstein, Bronn, Klass. u. Ord. d. Thierreichs, iii., p. 1402; pl. cxxii., figs. 9, 10; pl. cxxvii., fig. 14, 1866.
    1882. *Loligo Bleekeri*, Brock, Zeitschr. f. wiss. Zool., xxxvi., p. 604.
    1886. ,, ,, App., Japanska Ceph., p. 31, pl. i., figs. 7-10.
    Japanese Region.
20. **L. japonica**, Stp., MS., Hoyle, Diagnoses II., p. 187, 1885; Chall. Ceph., p. 157, pl. xxiv., figs. 7-15, 1886.
    Japanese Region.
21. **L. galatheæ**, Stp., MS., Hoyle, Diagnoses II., p. 183, 1885; Chall. Ceph., p. 159, pl. xxvii., 1886.
    Indo-Malayan Region.
22. **L. subalata** (Gerv. et v. Ben.), E. et S.
    1838. *Sepiola subalata*, Gerv. et v. Ben., Bull. Acad. Sci. Bruxelles, v., p. 423.
    1852. *Loligo* ,, E. et S., Voy. "Bonite," p. 30, pl. iii., figs. 1-5.
    Indo-Malayan Region.
23. **L. Reynaudii**, d'Orb., Céph. acét., p. 315, pl. xxiv., 1839.
    South African Region.
24. **L. Plei**, Blv., Journ. de Phys., xcvi., p. 132, 1823.
    1839. *Loligo Plei*, d'Orb., Céph. acét., p. 312, pls. xvi.; xxiv., figs. 9-13.



Stanford University Libraries

1845. *Ommastrephes arabicus*, d'Orb., Moll. viv., p. 428.
1880. *Loligo arabica*, Stp., Ommat. Blækspr., p. 95.
Red Sea Region.

28. **L. australis**, Gray, B.M.C., p. 71, 1849.
Australian Region.

29. **L. chinensis**, Gray, B.M.C., p. 74, 1849.
Indo-Malayan Region.

30. **L. Emmakina**, Gray, B.M.C., p. 71, 1849.[1]
West Indian Region.

31. **L. Hardwickei**, Gray, B.M.C., p. 69, 1849.
Indo-Malayan Region.

32. **L. hemiptera**, Howell, Amer. Journ. Conch., iii., p. 239, pl. xiii., 1867.
West Indian Region.

33. **L. lanceolata**, Raf., Précis. découv. somiol., p. 29, 1814 (*nomen tantum*).
Mediterranean Region.

34. **L. odogadium**, Raf., *op. cit.*, p. 29 (*nomen tantum*).
Mediterranean Region.

35. **L. tricarinata**, Gray, B.M.C., p. 73, 1849.
South African Region.

36. **L. Gronovii**, Fér. et d'Orb., Céph. acét., p. 319, 1839.
1880. *Loligo Gronovii*, Stp., Ommat. Blækspr., p. 97.
Indo-Malayan Region.

Loliolus, Steenstrup, 1856.

1. **L. typus**, Stp., Hectocotyl., p. 194, pl. i., fig. 5, 1856.
Hab. ?

2. **L. affinis**, Stp., *op. cit.*, p. 194, pl. i., fig. 6.
Pacific Ocean.

3. **L. Steenstrupi**, Dall, Amer. Journ. Conch., vii., p. 97, 1871.
Californian Region.

Lolliguncula, Steenstrup, 1881.

1. **L. brevis** (Blainville), Steenstrup.
1823. *Loligo brevis*, Blv., Journ. de Phys., xcvi., p. 133.
1824. ,, *brevipinna* (?), Les., Journ. Acad. Nat. Sci. Philad., iii., p. 282, pl. x.
1839. ,, *brevis*, d'Orb., Céph. acét., p. 314; Calmars, pl. xiii., figs. 4-6; pl. xv., fig. 13; pl. xxiv., figs. 14-19.
1881. *Lolliguncula brevis*, Stp., Sepiadarium og Idiosepius, p. 242.
New England and West Indian Regions.

[1] This is very close to, if not identical with, *L. brasiliensis*.

Division II. Œgopsida, d'Orbigny, 1839.

Family X. Ommastrephini, Steenstrup, 1861.

Subfamily Thysanoteuthidæ, Keferstein, 1866.

Thysanoteuthis, Troschel, 1857.

1. **T. rhombus**, Trosch., Archiv f. Naturgesch., xxiii., 1, p. 70, pl. iv., fig. 12; pl. v., figs. 1-4, 1857.
   1881. *Thysanoteuthis rhombus*, Vigelius, Mitth. Zool. Stat. Neapel, ii., p. 150.
   Mediterranean Region.
2. **T. elegans**, Troschel.
   1851. *Sepioteuthis sicula* (?), Vér., Céph. médit., p. 75, pl. xxvii.
   1857. *Thysanoteuthis elegans*, Trosch., Archiv f. Naturgesch., xxiii., 1, p. 74, pl. iv., figs. 10, 11.
   Mediterranean Region.

Subfamily Ommastrephidæ, Gill, 1871.

Ommastrephes, d'Orbigny, 1835.

Sthenoteuthis, Verrill.

1. **O. Bartramii** (Lesr.), d'Orb.
   1821. *Loligo Bartramii*, Lesr., Journ. Acad. Nat. Sci. Philad., ii., p. 90, pl. vii.
   1835. *Ommastrephes Bartramii*, d'Orb., Amér. mérid., p. 55.
   1835. ,, *cylindricus*, d'Orb., Céph. acét., p. 54, pl. iii.,

Oxford University Libraries

1856. *Ommatostrephes pteropus*, Stp., Vid. Meddel. nat. Foren. Kjöbenhavn, 1855, p. 117.
1862. ,, ,, Stp., *op. cit.*, 1861, p. 285.
1880. *Sthenoteuthis* ,, Vll., Ceph. N. E. Amer., p. 228, pl. xxvi.
1881. *Ommastrephes ensifer* (?), Owen, Trans. Zool. Soc. Lond., xi., 5, p. 144, pl. xxviii.
1885. *Ommatostrephes pteropus*, Stp., Notæ Teuthol., V.

Atlantic Ocean; Scandinavian and Mediterranean Regions.

4. **O. oualaniensis** (Lesson), d'Orb.

1830. *Loligo oualaniensis*, Less., Voy. "Coquille," Zool., p. 240, pl. i., fig. 2.
1832. ,, *vanikoriensis*, Q. et G., Voy. "Astrolabe," ii., p. 79, pl. v., figs. 1, 2.
1832. ,, *breviteutaculata*, Q. et G., *op. cit.*, p. 81.
1839. *Ommastrephes oualaniensis*, d'Orb., Céph. acét., p. 351, pls. iii., xxi.; pl. i., figs. 14, 15.
1862. ,, *Tryonii* (?), Gabb, Proc. Acad. Nat. Sci. Philad., p. 483, with plate.
1863. ,, *Ayresii* (?), Gabb, Carpenter, Rep. W. C. Moll., p. 613.
1880. *Ommatostrephes oualaniensis*, Stp., Ommat. Blækspr., pp. 76, 84, etc.
1886. *Ommastrephes* ,, Hoyle, Chall. Ceph., p. 162.

Indian and Pacific Oceans.

5. **O. pelagicus** (Bosc), d'Orb.

1802. *Sepia pelagica*, Bosc, Hist. nat., Vers, i., p. 46, pl. i., figs. 1, 2.
1839. *Ommastrephes pelagicus*, d'Orb., Céph. acét., p. 348, pl. xviii., figs. 1, 2; pl. i., figs. 17, 18.
1849. ,, ,, Gray, B.M.C., p. 63 (subgen. *Hyaloteuthis*).

Atlantic Ocean; West Indian Region.

6. **O. megapterus** (Vll.), Stp.

1878. *Architeuthis megaptera*, Vll., Amer. Journ. Sci., xvi., p. 207.
1880. *Sthenoteuthis* ,, Vll., Ceph. N. E. Amer., pp. 223, 286, pl. xxi., figs. 1-9; pl. xxvi.
1880. *Ommatostrephes megapterus*, Stp., Sthen. og Lest., pp. 3-8.

New England Region.

(Species insufficiently characterised.)

7. **O. eblanæ** (Ball), Gray.

1841. *Loligo Eblanæ*, Ball, Proc. Roy. Irish Acad., i., p. 363, figs. 1-7.
1850. *Ommastrephes Eblanæ*, Forbes and Hanley, Brit. Moll., vol. iv., p. 235, pl. sss., fig. 2.

Lusitanian Region.

8. **O. insignis**, Gld., Moll.-Wilkes Exped., p. 480, fig. 594, 1852.
   Southern Ocean; Pacific Insular Region.
9. **O. crassus**, Lafont, Actes Linn. Soc. Bordeaux, xxviii., p. 275, pl. xvi., 1871.
   Lusitanian Region.
10. **O. æquipodus** (Rüpp.).[1]
    1844. *Loligo æquipoda*, Rüpp., Giorn. Gab. Messina, xxvi. (*fide* Vér.).
    1851. ,, ,, Vér., Céph. médit., p. 105, pl. xxxv., figs. *a*, *b*.
    Mediterranean Region.

Dosidicus, Steenstrup, 1857.

1. **D. Eschrichtii**, Stp., Oversigt K. D. Vid. Selsk. Forhandl., p. 11, 1857; Ommat. Blækspr., pp. 79, 81, 89, with woodcuts.
   Mediterranean Region.
2. **D. Steenstrupii**, Pffr., Ceph. Hamb. Mus., p. 20, fig. 27, 1884.
   Hab.?

Todarodes, Steenstrup, 1880.

Ommastrephes, d'Orbigny (*pars*).

1. **T. sagittatus** (Lmk.), Stp.
   1758. *Loliginis species maxima*, Seba, Rer. Nat. Thes., iii., pl. iv., figs. 1, 2.
   1799. *Loligo sagittata*, Lmk., Mém. Soc. Hist. Nat. Paris, i., p. 13.
   1829. ,, *todarus*, d. Ch., Mem. stor. anim., iv., p. 161, pl. lx.

Stanford University Libraries

Illex, Steenstrup, 1880.

Ommastrephes, d'Orbigny (*pars*).

1. **I. illecebrosus** (Lesr.), Stp.

1821. *Loligo illecebrosa*, Lesr., Journ. Acad. Nat. Sci. Philad., ii., p. 95.
1825. ,, *piscatorum*, La Pylaie, Ann. Sci. Nat. [1], iv., p. 319.
1839. *Ommastrephes sagittatus*, d'Orb., Céph. acét., p. 345, pls. iv., vi. (*pars*).
1880. *Illex illecebrosus*, Stp., Ommat. Blækspr., pp. 82, 90, etc.
1881. *Ommastrephes illecebrosa*, Vll., Ceph. N. E. Amer., p. 268, pl. xxviii.; pl. xxix., fig. 5; pl. xxxvii., fig. 8; pl. xxxix.

Atlantic Ocean; New England Region.

2. **I. Coindetii** (Vér.), Stp.

1837. *Loligo Coindetii*, Vér., Mem. Accad. Sci. Torino, i., p. 94, pl. iv.
1839. *Ommastrephes sagittatus*, d'Orb., Céph. acét., p. 345, pl. i., figs. 1-10 (*pars*).
1851. *Loligo Pillæ* (?), Vér., Céph. médit., p. 112, pl. xxxvi., figs. d-g.
1880. *Illex Coindetii*, Stp., Ommat. Blækspr., pp. 82, 90, etc.

Scandinavian, Lusitanian, and Mediterranean Regions.

Architeuthus, Steenstrup, 1856.[1]

Architeuthis, Auctt.

1. **A. monachus**, Stp., Skand. Naturf. Forhandl., vii., p. 182, 1857 (*nomen tantum*).

1861. *Architeuthis dux*, Harting, Verhandel. k. Akad. Weten., ix., p. 11, pl. i.
1880. ,, *monachus*, Vll., Ceph. N. E. Amer., pp. 238-245.
1880. ,, *Hartingii* (?), Vll., *op. cit.*, p. 240.

Atlantic Ocean.

2. **A. dux**, Stp., Skand. Naturf. Forhandl., vii., p. 182, 1857 (*nomen tantum*).

1862. *Loligo Bouyeri* (?), Crosse et Fischer, Journ. de Conch. [3], ii., p. 138.
1875. *Architeuthis dux*, Gervais, Journ. de Zool., iv., p. 90.
1880. ,, ,, Vll., Ceph. N. E. Amer., p. 238.

Atlantic Ocean; Scandinavian Region.

3. **A. harveyi** (Kent), Vll.

1874. *Megaloteuthis Harveyi*, Kent, Proc. Zool. Soc., pp. 178, 489.
1880. *Architeuthis* ,, Vll., Ceph. N. E. Amer., p. 197, pls. xiii.-xvia.
1882. ,, ,, Vll., *op. cit.*, p. 422.

Atlantic Ocean; New England Region.

[1] For generic characters see Steenstrup, Ommat. Blækspr., p. 102; and Vll., Ceph. N. E. Amer., p. 197.

4. **A. princeps**, Vll., Amer. Journ. Sci., ix., pp. 124, 181, pl. v., 1875.

1880. *Architeuthis princeps*, Vll., Ceph. N. E. Amer., p. 210, pls. xvii.-xx.

Atlantic Ocean; New England Region.

5. **A. Martensi** (Hilgdf.), Stp.

1880. *Megateuthus Martensii*, Hilgdf., Sitzungsb. naturf. Freunde Berlin, p. 65.

1882. *Architeuthus martensii*, Stp., Notæ Teuthol. III., p. 157.

Japanese Region.

6. **A. grandis** (Owen), Vll.

1881. *Plecioteuthis grandis*, Owen, Trans. Zool. Soc., xi., 5, p. 156, pls. xxxiv., xxxv.

1881. *Architeuthis* ,, Vll., Ceph. N. E. Amer., p. 400.

1882. *Architeuthus* sp., Stp., Notæ Teuthol. IV., p. 164.

Hab. ?

Mouchezia,[1] Vélain, 1877.

1. **M. Sancti-Pauli**, Vélain, Archives Zool. expér., vi., p. 83, fig. 8 (*err. typ.?*).

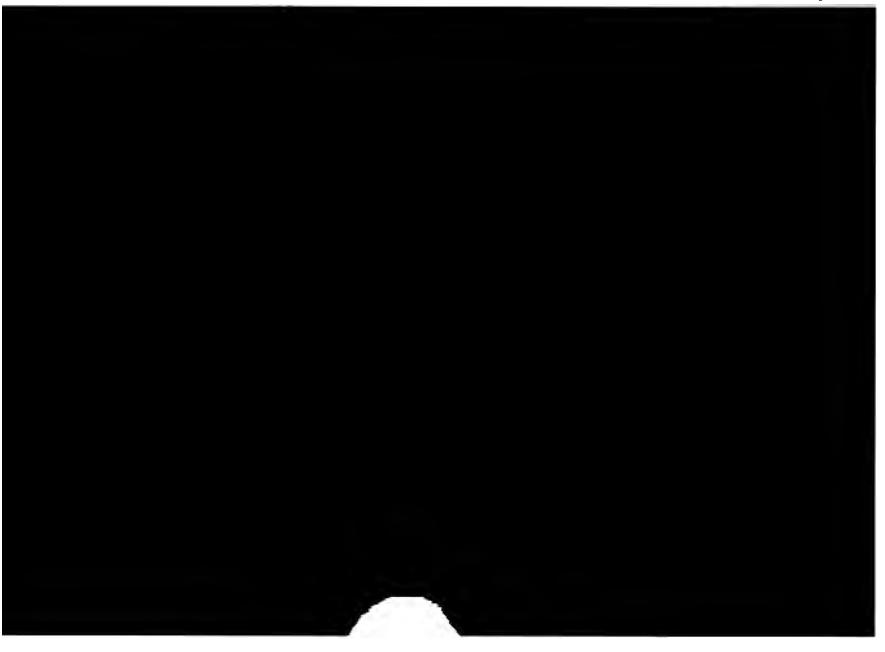
South African Region.

Tracheloteuthis, Steenstrup, 1881.

Verrilliola, Pffr.

Entomopsis, Rochebr. (?).

1. **T. Riisei**, Stp., Vid. Meddel. nat. Foren. Kjöbenhavn, p. 294,



Stanford University Libraries

Bathyteuthis, Hoyle, 1885.

Benthoteuthis, Verrill.

1. **B. abyssicola**, Hoyle, Narr. Chall. Exp., p. 272, fig. 108, 1885; Chall. Ceph., p. 168, pl. xxix., figs. 1-7, 1886.
   Southern Ocean.
2. **B. megalops** (Vll.).
   1885. *Benthoteuthis megalops*, Vll., Third Catal., p. 402, pl. xliv., fig. 1.
   Atlantic Ocean.

Steenstrupiola, Pfeffer, 1884.

1. **S. chilensis**, Pffr., Ceph. Hamb. Mus., p. 16, fig. 20, 1884.
   Peruvian Region.[1]
2. **S. atlantica**, Pffr., *op. cit.*, p. 17, fig. 21.
   Atlantic Ocean.

Subfamily Mastigoteuthidæ, Verrill, 1881.

Mastigoteuthis, Verrill, 1881.

1. **M. Agassizii**, Vll., "Blake" Rep., p. 100, pls. i.; ii., figs. 2, 3, 1881; Ceph. N. E. Amer., p. 297, pls. xlviii., xlix., figs. 2, 3.
   1886. *Mastigoteuthis agassizii*, Hoyle, Chall. Ceph., p. 170, pl. xxix., figs. 8-10.
   Atlantic Ocean.

Family XI. Onychii, Steenstrup, 1861.

Subfamily Onychoteuthidæ, Gray, 1849 (*sensu stricto*).

Enoploteuthis, d'Orbigny, 1839.

1. **E. leptura** (Leach), d'Orb.
   1817. *Loligo lepturo*, Leach, Zool. Miscell., iii., p. 141 (*err. typ.*).
   1817. ,, *Smythii*, Leach, *Ibid.*
   1839. *Enoploteuthis leptura*, d'Orb., Céph. acét., p. 337, pl. vi.; pl. xi., figs. 6-14; pl. xii., figs. 10-24.
   1849. ,, *Smithii*, Gray, B.M.C., p. 47.
   Atlantic and Pacific Oceans.
2. **E. margaritifera**, Rüpp., Giorn. Gab. Messina, xxvi., p. 2, fig. 1, 1844 (*fide* Vér.).
   1851. *Enoploteuthis margaritifera*, Vér., Céph. médit., p. 82, pl. xxx., fig. a.
   1858 ,, ,, Claus, Archiv f. Naturgesch., xxiv., 1, p. 262, Taf. x., fig. 2.

[1] Probably this species is oceanic, not littoral.

1886. *Enoploteuthis margaritifera*, Hoyle, Chall. Ceph., p. 171, pl. xxix., fig. 11.

Pacific Ocean; Mediterranean Region.

3. **E. pallida**, Pfr., Ceph. Hamb. Mus., p. 18, fig. 23, 1884.
Atlantic Ocean.

4. **E. Hoylei**, Pfr., *op. cit.*, p. 17, fig. 22.
South African Region.

Cucioteuthus, Steenstrup, 1882.

Enoploteuthis, Auctt. (*pars*).

1. **C. unguiculatus** (Molina), Stp.

1782. *Sepia unguiculata*, Molina, Saggio Stor. Nat. Chili, p. 199.
1818. *Onychoteuthis Molinæ*, Licht., Sepien mit Krallen, p. 13.
1861. ——————, Harting, Verhandel. k. Akad. Weten., ix., pl. iii., figs. 16, 17.
1881. *Enoploteuthis Cookii*, Owen, Trans. Zool. Soc. Lond., xi., 5, p. 150, pls. xxx.-xxxii.; pl. xxxiii., fig. 1 (*pars*).
1882. *Cucioteuthus unguiculatus*, Stp., Notæ Teuthol. III., p. 153.

Pacific Ocean.

Ancistrocheirus, Gray, 1849.

Enoploteuthis, Auctt. (*pars*).

1. **A. Lesueurii** (d'Orb. et Fér.), Gray.

1839. *Enoploteuthis Lesueurii*, d'Orb. et Fér., Céph. acét., p. 339, pl. xi., figs. 1-5; pl. xiv., figs. 4-10.
1849. *Ancistrocheirus* ... Gray, P.M.C., p. 49.

[redacted]

Stanford University Libraries

1849. *Abralia Morisii*, Gray, B.M.C., p. 50.

Atlantic Ocean.

3. **A. Veranyi** (Rüpp.).

1844. *Enoploteuthis Veranyi*, Rüpp., Giorn. Gab. Messina, xxvi., p. 3, fig. 2 (*fide* Vér.).

1851. ,, ,, Vér., Céph. médit., p. 83, pl. xxx., fig. b.

Mediterranean Region.

4. **A. Oweni** (Vér.).

1851. *Enoploteuthis Owenii*, Vér., Céph. médit., p. 84, pl. xxx., figs. c, d.

1858. ,, ,, Claus, Archiv f. Naturgesch., xxiv., 1, p. 261, pl. x., fig. 1.

Mediterranean Region.

5. **A. polyonyx** (Troschel).

1857. *Enoploteuthis polyonyx*, Trosch., Archiv f. Naturgesch., xxiii., 1, p. 87, pl. iv., fig. 9.

Mediterranean Region.

6. **A. megalops**, Vll., Amer. Journ. Sci., xxiv., p. 364, 1882; "Blake" Suppl., p. 105, pl. iii., fig. 4, 1883; Second Catal., p. 143, pl. xxviii., fig. 2, 1884.

West Indian Region.

Verania, Krohn, 1847.

Octopodoteuthis, Krohn et Rüppell, Gray.

1. **V. sicula** (Krohn).

1844. *Octopoteuthis sicula*, Rüpp., Giorn. Gab. Messina, xxvi., p. 6 (*fide* Vér.).

1845. *Octopodoteuthis* ,, Krohn, Archiv f. Naturgesch., xi., 1, p. 47, pl. v.

1851. *Verania* ,, Vér., Céph. médit., p. 78, pl. xxviii.

1884. *Octopodoteuthis* ,, Pfr., Ceph. Hamb. Mus., p. 28.

Mediterranean Region.

Onychoteuthis, Lichtenstein, 1818.

1. **O. Banskii** (Leach), Fér.[1]

1817. *Loligo Banskii*, Leach, Zool. Miscell., iii., p. 141.

1839. *Onychoteuthis Banksii*, d'Orb. et Fér., Céph. acét., p. 332, pl. i.; pl. ii., figs. 1, 2; pls. iii.-v., figs. 1-3; pl. ix., fig. 1; pl. xii., figs. 1-9.

[1] This species has also at various times received the specific names *Lessonii*, *Bergii*, *Bartlingii*, *Bellonii*, *Fleurii*, a full account of which is given by d'Orbigny (*loc. cit.*); it is not quite certain, however, that these are all correctly referred to the same type.

1821. *Onykia angulata*, Less., Journ. Acad. Nat. Sci. Philad., ii., p. 99, pl. ix., fig. 3.

Atlantic, Indian, and Pacific Oceans; New Zealand Region.

2. **O. fusiformis**, Gabb, Proc. Calif. Acad. Nat. Sci., ii., p. 171, 1862.

Hab.?

3. **O. æquimanus**, Gabb, Amer. Journ. Conch., iv., p. 23, pl. ii., 1868.

Pacific Ocean.

4. **O. lobipennis**, Dall, Amer. Journ. Conch., vii., p. 96, 1872.

Californian Region.

5. **O. raptor**, Owen, Trans. Zool. Soc., xi., 5, p. 148, pl. xxix., 1881.

Hab.?

6. **O. ingens**, E. A. Sm., Proc. Zool. Soc., p. 25, pl. iii., fig. 1, 1881.

Patagonian Region.

7. **O. brachyptera**, Pfr., Ceph. Hamb. Mus., p. 20, fig. 26, 1884.

Peruvian Region.

(Species insufficiently characterised.)

8. **O. rutilus**, Gld., Moll. Wilkes Exped., p. 482, fig. 595, 1852.

Australian Region.

9. O. brevimanus, Gld., Moll. Wilkes Exped., p. 483, fig. 596.

Stanford University Libraries

2. **A. Dussumieri** (d'Orb.), Gray.

1839. *Onychoteuthis Dussumieri*, d'Orb., Céph. acét., p. 335, pl. xiii.
1849. *Ancistroteuthis* ,, Gray, B.M.C., p. 56.

Indian Ocean.

3. **A. robusta** (Dall), Stp.

1873. *? Onychoteuthis Bergi*, Dall, Amer. Nat., vii., p. 484.
1876. *Ommastrephes robustus*, Dall MS., Vll., Amer. Journ. Sci., xii., p. 236.
1880. *Onychoteuthis robusta*, Vll., Ceph. N. E. Amer., p. 246, pls. xxiii., xxiv.
1880. *Ancistroteuthis* ,, Stp., Sthen. og Lest., p. 19.
1881. *Moroteuthis* ,, Vll., Ceph. N. E. Amer., p. 393.
1882. *Ancistroteuthis* ,, Stp., Notæ Teuthol. II., p. 150.

Californian Region.

Teleoteuthis,[1] Verrill, 1882.

Onychia, Lesueur.
Onychoteuthis, Auctt. (*pars*).

1. **T. caribbæa** (Lesr.), Vll.

1821. *Onykia carribœa*, Lesr., Journ. Acad. Nat. Sci. Philad., ii., p. 98, pl. ix., figs. 1, 2 *a-e*.
1836. *Loligo laticeps*, Owen, Trans. Zool. Soc., ii., p. 108, pl. xxi., figs. 6-11.
1837. *Cranchia perlucida*, Rang, Mag. de Zool., pl. xciv.
1839. *Onychoteuthis cardioptera*, d'Orb., Céph. acét., p. 333, pl. i.; pl. v., figs. 4-6 (*pars ?*).
1849. *Onychia* ,, Gray, B.M.C., p. 57.
1851. *Loligo alessandrinii* (?), Vér., Céph. médit., p. 99, pl. xxxv., figs. f, g, h.
1882. *Teleoteuthis carribœa*, Vll., Ceph. N. E. Amer. (Fish Comm. Rep.), p. 70.
1884. *Onychia binotata* (?), Pfr., Ceph. Hamb. Mus., p. 19, fig. 24.
1886. *Teleoteuthis caribbœa*, Hoyle, Chall. Ceph., p. 172, pl. xxx., figs. 1-8.

Atlantic and Pacific (?) Oceans.

2. **T. platyptera** (d'Orb.), Vll.

1835. *Onychoteuthis platyptera*, d'Orb., Amér. mérid., p. 41, pl. iii., figs. 8-11.
1839. ,, ,, d'Orb., Céph. acét., p. 335, pl. x., figs. 8-10; pl. xiv., figs. 14-22.

Indian Ocean.

1 It is not without a feeling of regret that one abandons a generic name so time-honoured as that of Lesueur, but since the name is preoccupied, and since Verrill has proposed a new one, there seems no longer any excuse for retaining it.

3. **T. peratoptera** (d'Orb.).
   1835. *Onycholeuthis peratoptera*, d'Orb., Amér. mérid., p. 39, pl. iii., figs. 5-7.
   Indian Ocean.
4. **T. curta** (Pfir.).
   1884. *Onychia curta*, Pfir., Ceph. Hamb. Mus., p. 19, fig. 25.
   Indo-Malayan Region.
5. **T. Krohnii** (Vér.), Vll.
   1851. *Onycholeuthis Krohnii*, Vér., Céph. médit., p. 80, pl. xxix., figs. *d*, *e*.
   1851. *Loligo Bianconii* (?), Vér., *op. cit.*, p. 100, pl. xxxv., figs. *i-l*.
   1880. *Onychia Krohnii*, Stp., Sthen. og Lest., p. 19 (note).
   1882. *Teleoteuthis* ,, Vll., Ceph. N. E. Amer. (Fish. Comm. Rep.), p. 70.
   Mediterranean Region.
6. **T. agilis**, Vll., Third Catal., p. 400, pl. xlii., fig. 2, 1885.
   New England Region.
7. **T. (?) Meneghini**, Vér.
   1851. *Loligo Meneghini*, Vér., Céph. médit., p. 98, pl. xxxiv., figs. *c*, *e*.
   1880. *Onychia (?) Meneghini*, Stp., Ommat. Blækspr., p. 99.
   Mediterranean Region.

Subfamily Gonatidæ, Hoyle, 1886.

Gonatus, Gray, 1849.

Sepia Loligo, Fabricius.
Onycholeuthis, Lichtenstein, Möller, Middendorff.

Stanford University Libraries

1881. *Cheloteuthis rapax*, Vll., *op. cit.*, p. 293, pl. xlix., fig. 1.
1881. *Lestoteuthis Fabricii*, Vll., *op. cit.*, pp. 387-393, pl. xlv., figs. 1, 2; pl. xlix., fig. 1; pl. lv., fig. 1.
1882. *Gonatus* ,, Stp., Notæ Teuthol. I., p. 143.
1886. ,, ,, Hoyle, Chall. Ceph., p. 174.

Atlantic and Pacific Oceans; New England, Mediterranean, and Arctic Regions.

(Of uncertain relationship.)

——— **carunculata** (Schneider).

1788. *Sepia carunculata*, Schneider, Beobacht. u. Entdeck., Bd. v., p. 42 (*fide* d'Orb.).
1845. *Loligo* ,, d'Orb., Moll. viv., p. 352.

Hab.?

Family XII. Taonoteuthi, Steenstrup, 1861.

Subfamily Chiroteuthidæ, Gray, 1849.

Chiroteuthis, d'Orbigny, 1839.

Loligopsis, Férussac (*pars*).

1. **C. Veranyi** (Fér.), d'Orb.

1835. *Loligopsis Veranyi*, Fér., Mag. de Zool., ann. v., cl. v., pl. lxv.
1839. *Chiroteuthis* ,, d'Orb., Céph. acét., p. 325, pls. ii.; iv., figs. 17-23.
1851. *Loligopsis* ,, Vérany, Céph. médit., p. 120, pls. xxxviii., xxxix.

Mediterranean Region.

2. **C. Bonplandi** (Vér.), d'Orb.

1837. *Loligopsis Bomplandi*, Vér., Mem. Accad. Sci. Torino [2], i., p. 99, pl. i.
1839. *Chiroteuthis Bonplandi*, d'Orb., Céph. acét., p. 326.

Atlantic Ocean.

3. **C. lacertosa**, Vll.

1881. *Chiroteuthis bonplandi* (?), Vll., "Blake" Rep., p. 102, pl. iii., fig. 1.
1881. ,, *lacertosa*, Vll., Ceph. N. E. Amer., pp. 299, 408, pl. xlvii., fig. 1; pl. lvi., fig. 1.

Atlantic Ocean; New England Region.

Histiopsis, Hoyle, 1885.

1. **H. atlantica**, Hoyle.

1885. *Histiopsis atlantica*, Hoyle, Diagnoses II., p. 201, 1885; Chall. Ceph., p. 180, pl. xxx., figs. 9-15.

Atlantic Ocean.

Calliteuthis, Verrill, 1880.

Loligopsis, Owen (*pars*).

1. **C. reversa**, Vll., Amer. Journ. Sci., xx., p. 393, 1880; Ceph. N. E. Amer., p. 295, pl. xlvi., fig. 1, 1881; Second Catal., p. 243, 1884.

   1886. *Calliteuthis reversa*, Hoyle, Chall. Ceph., p. 183, pl. xxxiii., figs. 12-15.

   Atlantic Ocean; New England and Japanese Regions.

2. **C. ocellata** (Owen), Vll.

   1881. *Loligopsis ocellata*, Owen, Trans. Zool. Soc. Lond., xi., 5, pp. 139-143, pl. xxvi., figs. 3-8; pl. xxvii.

   1881. *Calliteuthis* ,, Vll., Ceph. N. E. Amer., p. 402.

   Japanese Region.

Brachioteuthis, Verrill, 1881.

1. **B. Beanii**, Vll., Ceph. N. E. Amer., p. 406, pl. lv., fig. 3; pl. lvi., fig. 2.

   Atlantic Ocean; New England Region.

Doratopsis, de Rochebrune, 1884.

Hyaloteuthis, Pfeffer.
Leptoteuthis, Verrill.

1. **D. vermicularis** (Rüpp.), Rochebr.[1]

   1844. *Loligopsis vermicularis*, Rüpp., Giorn. Gab. Messina, xxvi. (*fide* Vér.).

Stanford University Libraries

1884. *Hyaloteuthis vermicularis*, Pfir., Ceph. Hamb. Mus., p. 28, fig. 30.
1884. *Leptoteuthis vermicolaris*, Vll., Second Catal., p. 143.
1885. *Doratopsis vermicularis*, Hoyle, Loligopsis, p. 329.
Mediterranean Region.

2. **D. diaphana** (Vll.).
1884. *Leptoteuthis diaphana*, Vll., Second Catal., p. 141, pl. xxxii., fig. 1.
Atlantic Ocean.

Histioteuthis, d'Orbigny, 1839.

Cranchia, Férussac (*pars*).

1. **H. Bonelliana** (Fér.), d'Orb.
1835. *Cranchia Bonelliana*, Fér., Mag. de Zool., ann. v., cl. v., pl. lxvi.
1839. *Histioteuthis* ,, d'Orb., Céph. acét., p. 327, pl. ii.
Mediterranean Region.

2. **H. Ruppelli**, Vér., Céph. médit., p. 117, pls. xx., xxi.
Mediterranean Region.

3. **H. Collinsii**, Vll., Amer. Journ. Sci., xvii., p. 241, 1879; Ceph. N. E. Amer., pp. 234, 300, 404, pl. xxiii.; pl. xxvii., figs. 3-5; pl. xxxvii., fig. 5; pl. lv., fig. 6.
New England Region.

Family XIII. Cranchiæformes, Steenstrup, 1861.

Subfamily Cranchiadæ, Gray, 1849.

Cranchia, Leach, 1817.

1. **C. scabra**, Leach, Zool. Miscell., iii., p. 140, 1817.
1836. *Cranchia scabra*, Owen, Trans. Zool. Soc., ii., p. 105 (with figs.).
1838. *Philonexis Eylais*, d'Orb., Céph. acét., p. 102, pl. xvii., figs. 4, 5.
1861. *Cranchia scabra*, Stp., Overblik, p. 72.
Atlantic Ocean; West Indian Region.

2. **C. hispida**, Pfir., Ceph. Hamb. Mus., p. 27, fig. 37, 1884.
Hab. ?

that the shortness of the mantle was due to its having been folded, a fact which had not been observed owing to the transparency of the animal, and that the difference in the fin is owing to mutilation. The gladius, so far as he was able to examine it, presents some resemblance to the curious pen elsewhere described (Chall. Ceph., p. 178).

Dr Pfeffer's generic name being invalid, it would be necessary to change the family name, which he has proposed (Hyaloteuthidæ), to correspond with the one which has the preference, but I think that for the present this form may be placed among the Chiroteuthidæ.

3. **C. tenuitentaculata**, Pffr., *op. cit.*, p. 26, fig. 36.
   West Indian Region.

4. **C. megalops**, Prosch, K. d. Vid. Selsk. Skr. [5], i., p. 64, 1847.
   1861. *Cranchia megalops*, Stp., Overblik, p. 77.
   Atlantic Ocean.

5. **C. (?) maculata**, Leach, Zool. Miscell., iii., p. 140, 1817.[1]
   1886. *Cranchia* (?) *maculata*, Hoyle, Chall. Ceph., p. 186.
   Atlantic Ocean.

Subgenus, Liocranchia, Pfeffer, 1884.

6. **C. Brockii** (Pffr.).
   1884. *Liocranchia Brockii*, Pffr., Ceph. Hamb. Mus., p. 25, fig. 33.
   Indo-Malayan Region.

7. **C. Reinhardtii**, Stp.
   1856. *Leachia Reinhardtii*, Stp., Hectocotyl., p. 200.
   1861. *Cranchia* ,, Stp., Overblik, p. 76.
   1884. *Liocranchia* ,, Pffr., Ceph. Hamb. Mus., p. 25.
   1886. *Cranchia* ,, Hoyle, Chall. Ceph., p. 184, pl. xxxi., figs. 11-14; pl. xxxii., figs. 1-4.
   Atlantic Ocean.

Taonius, Steenstrup, 1861.

Loligopsis, d'Orbigny, Tryon, de Rochebrune, etc.
Desmoteuthis, Verrill.
Procalistes, Lankester.
Phasmatopsis, de Rochebrune.
Megalocranchia (?), Pfeffer.

Stanford University Libraries

3. **T. cymoctypus** (Rochebr.), Hoyle.

1839. *Loligopsis pavo*, d'Orb., Céph. acét., p. 321, pl. vi., fig. 4 (?); pl. xxiii., figs. 10, 11 (*pars*).
1884. *Phasmatopsis cymoctypus*, Rochebr., Monogr. Loligopsidæ, p. 17, pl. i.
1885. *Taonius* ,, Hoyle, Loligopsis, p. 323.

Madeira.

4. **T. Suhmi** (Lankester), Hoyle.

1884. *Procalistes Suhmii*, Lankester, Quart. Journ. Micr. Sci., vol. xxiv., p. 311.
1886. *Taonius suhmi*, Hoyle, Chall. Ceph., p. 192, pl. xxxii., figs. 5-11.

Atlantic, Southern, and Pacific Oceans.

5. **T. elongatus**, Stp., MS.

1886. *Taonius elongatus*, Hoyle, Chall. Ceph., p. 189, pl. xxviii., fig. 13.

Hab. ?

6. **T. Schneehageni** (Pffr.).[1]

1884. *Loligopsis Schneehageni*, Pffr., Ceph. Hamb. Mus., p. 23, fig. 31, 1884.

Peruvian Region.

7. **T. (?) maximus** (Pffr.).[2]

1884. *Megalocranchia maxima*, Pffr., *op. cit.*, p. 24, fig. 32.

South African Region.

Pyrgopsis, de Rochebrune, 1884.

1. **P. rhynchophorus**, Rochebr., Monogr. Loligopsidæ, p. 23, pl. ii., figs. 1-6, 1884.

South African Region.

Leachia, Lesueur, 1821; Steenstrup, 1861.

Anisoctus (?), Rafinesque.
Loligopsis (*pars*), d'Orbigny, Auctt.
Dyctydiopsis, de Rochebrune.
Perothis, Rathke.

1. **L. cyclura**, Lesr., Journ. Acad. Nat. Sci. Philad., ii., p. 90, pl. vi., 1821.

1833. *Loligopsis guttata*, Grant, Trans. Zool. Soc., i., p. 24, pl. ii.
1833. *Perothis pellucida*, Rathke, Mém. Savans Étrang. St. Petersb., ii., p. 149.
1833. ,, *Escholtzii*, Rathke, *Ibid.*
1861. *Leachia cyclura*, Stp., Overblik, p. 82.

[1] Dr Pfeffer has been good enough to furnish me with a number of additional particulars regarding this form, which leave no doubt that it should be referred to the genus *Taonius*.

[2] If I am correct in referring this form to the genus *Taonius*, the specific designation is singularly unfortunate; *minimus* would have been more appropriate; but in the present state of our knowledge it is not worth while to burden the animal with another name, more especially as it is not improbably the young of one of the other forms.

1884. *Perothis Dussumieri*, Rochebr., Monogr. Loligopsidæ, p. 28.
1885. *Leachia cyclura*, Hoyle, Loligopsis, p. 326.
Atlantic, Indian, and Pacific Oceans.

2. **L. ellipsoptera** (Ad. and Rv.), Stp.
1848. *Loligopsis ellipsoptera*, Ad. and Rv., Voy. "Samarang," Moll., p. 2.
1861. *Leachia* ,, Stp., Overblik, p. 80.
1884. *Dyctydiopsis* ,, Rochebr., Monogr. Loligopsidæ, p. 18.
1885. *Leachia* ,, Hoyle, Loligopsis, p. 328.
Atlantic Ocean.

3. **L. dubia** (Rathke), Hoyle.
1833. *Perothis dubia*, Rathke, Mém. Savans Étrang. St. Petersb., ii., p. 170.
1885. *Leachia* ,, Hoyle, Loligopsis, p. 329.
Indian Ocean.

Loligopsis,[1] Lamarck, 1812.

Loligopsis, Auctt. (*pars*).

1. **L. Peronii**, Lmk., Extrait de son Cours de Zool., p. 123, 1812 (*fide* d'Orb.).
1861. *Loligopsis Peronii*, Stp., Overblik, p. 85.
1885. ,, ,, Hoyle, Loligopsis, p. 314.
Pacific Ocean (?).

2. **L. zygæna**, Vér., Céph. médit., p. 125, pl. xl., fig. *c*, 1851.[2]
1884. *Zygænopsis zygæna*, Rochebr., Monogr. Loligopsidæ, p. 20.
1885. ————(?) ,, Hoyle, Loligopsis, p. 331.
Mediterranean Region.

Order II. TETRABRANCHIATA, Owen, 1832.

Stanford University Libraries

1886. *Nautilus pompilius*, Hoyle, Chall. Ceph., p. 199.

Australian and Pacific Insular Regions.

2. **N. scrobiculatus**, Sol., Portl. Catal., No. 3653.

1868. *Nautilus scrobiculatus*, Küster, Conch. Cab., sec. 55, p. 9, pl. 3, figs. 1, 2.

Pacific Insular Region.

3. **N. macromphalus**, Sowerby, Thes. Conch., p. 464, pl. xcviii., figs. 4, 5, 1848.

1868. *Nautilus macromphalus*, Küster, Conch. Cab., sec. 55, p. 10, pl. 3a.

Pacific Insular Region.

4. **N. umbilicatus**, Lister, Conch., pl. 552, fig. 4.

1868. *Nautilus umbilicatus*, Küster, Conch. Cab., sec. 55, p. 10, pl. 3c., fig. 2.

Pacific Insular Region.

5. **N. stenomphalus**, Sowerby, Thes. Conch., p. 469, pl. xcvii., fig. 3, 1848.

1868. *Nautilus stenomphalus*, Küster, Conch. Cab., sec. 55, p. 11, pl. 3b.

Australian Region.

Explanation of the more Abbreviated References.

App., Japanska Ceph.,—Appellöf, Japanska Cephalopoder, *K. Svensk. Vetensk. Akad. Handl.*, xxi., 13, pp. 1-40, pls. i.-iii., 1886.

D. Ch., Mem. stor. anim.,—delle Chiaje, Memorie sulla storia e notomia degli animali senza vertebre del regno di Napoli, iv. Napoli, 1829.

E. et S., Voy. "Bonite,"—Eydoux et Souleyet, Voyage autour du Monde exécuté pendant les années 1836 et 1837, sur la corvette la Bonite, commandée par M. Vaillant.—Zoologie, ii. Paris, 1852.

Gld., Moll. Wilkes Exped.,—Gould, United States Exploring Expedition during the years 1838, 1839, 1840, 1841, 1842, under the Command of Charles Wilkes, U.S.N.—xii., Mollusca and Shells. Boston, 1852.

Gray, B. M. C.,—Catalogue of the Mollusca in the Collection of the British Museum.—I., Cephalopoda Antepedia. London, 1849.

Hoyle, Diagnoses I., II.,—Diagnoses of new Species of Cephalopoda collected during the Cruise of H.M.S. "Challenger."—I. The Octopoda, *Ann. and Mag. Nat. Hist.* [5], xv., pp. 222-236; II. The Decapoda, *op. cit.*, xvi., pp. 181-203, 1885.

,, **Prelim. Rep. I., II.**,—Preliminary Report on the Cephalopoda collected during the Cruise of H.M.S. "Challenger."—I. The Octopoda, *Proc. Roy. Soc. Edin.*, xiii., pp. 94-114; II. The Decapoda, *op. cit.*, pp. 281-310, 1885.

,, **Loligopsis**,—On Loligopsis and some other genera, *Proc. Roy. Phys. Soc. Edin.*, viii., pp. 313-333, 1885.

Hoyle, Chall. Ceph.,—Report on the Cephalopoda collected by H.M.S. "Challenger" during the years 1873-76, 246 pp., 33 pls.—Zool. Chall. Exp., part xliv., 1886.

Issel, Malacol. Mar Rosso,—Malacologia del Mar Rosso, ricerche zoologiche e paleontologiche. Pisa, 1869.

Lenz, Jahresb. Comm. Kiel,—Jahresbericht der Commission zur wissenschaftlichen Untersuchung der deutschen Meere in Kiel, Jahrgang i., etc., 1871, etc.

D'Orb., Amér. mérid.,—D'ORBIGNY, Voyage dans l'Amérique méridionale exécuté pendant les années, 1826-33.—v., 3, Mollusques. Paris et Strasbourg, 1835-43.

,, **Moll. viv.**,—Mollusques vivants et fossiles. Paris, 1845 and 1855.

,, **Moll. Cuba**,—Histoire physique, politique et naturelle de l'Ile de Cuba, par M. Ramon de la Sagra.—Mollusques par Alcide d'Orbigny. Paris, 1853.

,, **Céph. acét.**,—Histoire naturelle générale et particulière des céphalopodes acétabulifères, vivants et fossiles. Paris, 1835-48.

(Some of the plates of this work appear to have been issued prior to this date, for d'Orbigny quotes species as having been published in them as early as 1825.)

Pfr., Ceph. Hamb. Mus.,—PFEFFER, Die Cephalopoden des Hamburger Naturhistorischen Museums. — i., Neue Decapoden, *Abhandl. Naturw. Ver. Hamburg*, viii., 1, pp. 1-30, pls. i.-iii., 1884.

Q. et G., Voy. "Astrolabe,"—QUOY ET GAIMARD, Zoologie du Voyage de l'Astrolabe, sous les ordres du Capitaine Dumont d'Urville, pendant les années 1826-29, ii. Paris, 1832.

Raf., Good Book,—RAFINESQUE, On the 3 genera of Cephalopodes—Ocythoe, Todarus, and Anisoctus. *The Good Book and Amenities of Nature, or Annals of Historical and Natural Sciences.* Philadelphia, 1840.

(The references to this paper are given on the authority of Binney

Stanford University Libraries

Stp., Overblik,—Overblik over de i Kjöbenhavns Museer opbevarede Blæksprutter fra det aabne Hav, *Oversigt K. D. Vid. Selsk. Forhandl.*, pp. 69-86, 1861.

,, **Hemisep.,**—Hemisepius, en ny Slægt af Sepia-Blæksprutternes Familie, med Bemærkninger om Sepia-Formerne i Almindelighed, *K. d. Vid. Selsk. Skr.* [5], vii., pp. 465-482, pls. i., ii., 1875.

,, **Ommat. Blækspr.,**—De Ommatostrephagtige Blæksprutters indbyrdes Forhold, *Oversigt K. D. Vid. Selsk. Forhandl.*, pp. 73-110, pl. iii., 1880.

,, **Sthen. og Lest.,**—Professor A. E. Verrils to nye Cephalopodslægter: Sthenoteuthis og Lestoteuthis. *Oversigt K. D. Vid. Selsk. Forhandl.*, pp. 1-27, 1880.

,, **Sepiella,**—Sepiella Gray, Stp., *Vid. Meddel. nat. Foren. Kjöbenhavn*, pp. 349-356, figs. 1-8, 1880.

,, **Sep. og Idiosep.,**—Sepiadarium og Idosepius, to nye Slægter af Sepiernes Familie, med Bemærkninger om de to beslægtede Former Sepioloidea D'Orb. og Spirula Lmk., *K. d. Vid. Selsk. Skr.* [6], i., pp. 213-242, pl. i., 1881.

,, **Notæ Teuthol.,**—Notæ Teuthologicæ, *Oversigt K. D. Vid. Selsk. Forhandl.*, pp. 143-168, 1882; pp. 109-127, 1885.

Targ., Cef. Mus. Firenze,—Targioni-Tozzetti, Commentario sui Cepalopodi mediterranei del R. Museo di Firenze, *Bull. malacol. ital.*, ii., pp. 141-162, 209-252, 1869.

(The paging in the references is taken from the separate copy.)

Vér., Céph. médit.,—Vérany, Mollusques méditerranéens, observés, décrits, figurés et chromolithographiés d'apres le vivant, i., Céphalopodes de la Méditerranée. Gênes, 1851.

Vll., "Blake" Rep.,—Verrill, Reports on the Results of Dredging, under the Supervision of Alexander Agassiz, on the East Coast of the United States during the Summer of 1880, by the U. S. Coast Survey Steamer "Blake," Commander J. R. Bartlett, U.S.N., Commanding. X.—Report on the Cephalopods, and on some additional Species dredged by the U. S. Fish Commission Steamer "Fish Hawk" during the Season of 1880, *Bull. Mus. Comp. Zoöl.*, viii., pp. 99-116, pls. i.-viii., 1881.

,, **"Blake" Suppl.,**—Reports on the Results of Dredging, under the Supervision of Alexander Agassiz, in the Gulf of Mexico and in the Caribbean Sea (1878-79), by the U. S. Coast Survey Steamer "Blake," Lieut.-Commander C. D. Sigsbee, U.S.N., and Commander J. R. Bartlett, U.S.N., Commanding. XXIV.—Supplementary Report on the "Blake" Cephalopods, *op. cit.*, xi., pp. 105-115, pls. i.-iii., 1883. Descriptions of Two Species of Octopus from California, pp. 117-124, pls. iv.-vi.

,, **Ceph. N. E. Amer.,**—The Cephalopods of the North-Eastern Coast of America. Part I.—The Gigantic Squids (*Architeuthis*) and their Allies; with observations on similar large Species from foreign localities, *Trans. Connect. Acad.*, v., pp. 177-257, pls. xiii.-xxv., 1880: Part II.—The Smaller Cephalopods, including the "Squids" and the Octopi, with other allied forms, *op. cit.*, pp. 259-446,

pls. xxvi.-xli., xlv.-lvi., 1881. Reprinted, with scarcely any variation, in "Annual Report of the Commissioner of Fish and Fisheries for 1879," Washington, 1882.

(In references to the pages and plates, the former of these places is quoted as having been first published, in addition to which the index attached to the Fish Commission Report renders the indication of pages in it less necessary.)

VII., **Second Catal.**,—Second Catalogue of Mollusca recently added to the Fauna of the New England Coast and the adjacent parts of the Atlantic, consisting mostly of Deep-Sea Species, with Notes on others previously recorded, *Trans. Connect. Acad.*, vi., pp. 139-294, pls. xxviii.-xxxii., 1884.

,, **Third Catal.**,—Third Catalogue of Mollusca recently added to the Fauna of the New England Coast and the adjacent parts of the Atlantic, consisting mostly of Deep-Sea Species, with Notes on others previously recorded, *op. cit.*, pp. 395-452, pls. xlii.-xliv., 1885.

INDEX OF AUTHORITIES.

This List is intended to serve the purpose of a Bibliography of the works referred to in the present Catalogue, arranged under author's name. Only those pages therefore are indicated where reference to published works is made, and preference is given to those where the quotation is fullest.

Adams, 226.
Adams and Reeve, 213.
Appellöf, 259.
Audouin, 231.
Gervais and van Beneden, 227, 240.
Gesner, 226.
Gould, 259.
Leuckart, 237.
Lichtenstein, 248.
Linné, 212, 230.
Lovén, 228.

Stanford University Libraries

Reynaud, 215.
Risso, 213.
Rochebrune, A. T. de, 222, 225, 260.
Rüppell, 229.
Sars, 219.
Schneider, 238, 253.
Seba, 244.
Shaw, 212.
Smith, E. A., 228, 260.
Solander, 212.
Sowerby, 259.
Steenstrup, 214, 215, 243, 244, 246, 260.
Tapparone-Canefri, 234.
Targioni-Tozzetti, 261.
Tiberi, 223.
Troschel, 223.
Tryon, 214.
Vélain, 246.
Vérany, 213, 261.
Verrill, 211, 215, 227, 246, 249, 255, 261.
Vigelius, 242.

INDEX OF SYSTEMATIC NAMES.

NOTE.—*Synonyms are printed in less conspicuous type.*

	Page
Abralia, *Gray*,	248
armata (*Q. et G.*),	248
megalops, *Vll.*,	249
morisii (*Vér.*),	248
oweni (*Vér.*),	249
polyonyx (*Trosch.*),	249
veranyi (*Rüpp.*),	249
Acanthosepion, Rochebr.	230
enoplon, Rochebr.,	235
goreense, Rochebr.,	235
hasselti, Rochebr.,	232
javanicum, Rochebr.,	234
oculiferum, Rochebr.,	235
spinigerum, Rochebr.,	232
ALLOPOSIDÆ, *Vll.*,	215
Alloposus, *Vll.*,	215
mollis, *Vll.*,	215
Ammonia *levis*,	230
Amphioctopus, Fischer,	217
membranaceus (Q. et G.),	217
AMPHITRETIDÆ, *Hoyle*,	212
Amphitretus, *Hoyle*,	212
pelagicus, *Hoyle*,	212
Ancistrocheirus, *Gray*,	248
lesueurii (*d'Orb. et Fér.*),	248
megaptera, *Vll.*,	248
Ancistroteuthis, *Gray*,	250
dussumieri (*d'Orb.*),	251
lichtensteinii (*Fér.*),	250
robusta (*Dall*),	251
Anisoctus, Raf.,	257
Architeuthis,	245
dux, Harting,	245
grandis, Vll.,	246
hartingii, Vll.,	245
harveyi (Kent),	245
megaptera, Vll.,	243
monachus, Stp.,	245
princeps, Vll.,	246
sp.,	246
Architeuthus, *Stp.*,	245
dux, *Stp.*,	245
grandis (*Owen*),	246
harveyi (*Kent*),	245
martensi (*Hilg.*),	246

	Page
Architeuthus—*continued.*	
monachus, *Stp.*,	245
princeps, *Vll.*,	246
Argonauta, *L.*,	212
argo, *L.*,	212
bœttgeri, *Maltzan*,	213
expansa, *Dall*,	213
gondola, Ad. et. Rv.,	213
gondola, Dillw.,	213
gracilis, *Kirk*,	213
gruneri, Dkr.,	212
haustrum, Dillw.,	212
hians, *Soland.*,	213
kochiana, Dkr.,	213
navicula, Soland.,	212
nitida, Lmk.,	213
nodosa, Soland.,	212
oryzata, Meuschen,	213
owenii, Ad. et Rv.,	213
pacifica, *Dall*,	213
tuberculata, *Shaw*,	212
tuberculosa, Lmk.,	213
ARGONAUTIDÆ, *Cantr.*,	212
Ascarosepion, Rochebr.,	230
verreauxi, Rochebr.,	231
Bathyteuthis, *Hoyle*,	247
abyssicola, *Hoyle*,	247
megalops (*Vll.*),	247
Benthoteuthis, Vll.,	247
megalops, Vll.,	247
Bolitæna, *Stp.*,	225
microcotyla, *Stp.*,	225
Brachioteuthis, *Vll.*,	254
beanii, *Vll.*,	254
Bostrychoteuthis, Ag.,	211
Calliteuthis, *Vll.*,	254
ocellata (*Owen*),	254
reversa, *Vll.*,	254
Cheloteuthis, Vll.,	252
rapax, Vll.,	253
CHIROTEUTHIDÆ, *Gray*,	253
Chiroteuthis, *d'Orb.*,	253
bonplandi (*Vér.*),	253
lacertosa, *Vll.*,	253
veranyi (*Fér.*),	253

	Page
Chondrosepia, Lkt.,	236
loliginiformis, Lkt.,	237
Cirroteuthidæ, Kef.,	211
Cirroteuthis, *Eschr.*,	211
magna, *Hoyle*,	211
meangensis, *Hoyle*,	211
megaptera, *Vll.*,	211
mülleri, *Eschr.*,	211
pacifica, *Hoyle*,	211
plena, *Vll.*,	211
umbellata, *Fischer*,	211
Cistopus, *Gray*,	223
bursarius, *Stp.*,	223
indicus (*Rapp*),	223
Cranchia, Fér.,	255
Cranchia, *Leach*,	255
bonelliana, Fér.,	255
brockii (*Pfft.*),	256
hispida, *Pfft.*,	255
maculata, *Leach*,	256
megalops, *Prosch*,	256
minima, Fér.,	229
perlucida, Rang,	251
reinhardtii, *Stp.*,	256
scabra, *Leach*,	255
tenuitentaculata, *Pfft.*,	256
CRANCHIÆFORMES, *Stp.*,	255
CRANCHIADÆ, *Gray*,	255
Cucioteuthus, *Stp.*,	248
unguiculatus (*Molina*),	248
DECAPODA, *Leach*,	225
Desmoteuthis, Vll.,	256
hyperborea, Vll.,	256
tenera, Vll.,	256
DIBRANCHIATA,	211
Diphtherosepion, Roch.,	230
dabryi, Rochebr.,	236
martini, Rochebr.,	236
Doratopsis, *Rochebr.*,	254
diaphana (*Vll.*),	255
rüppelli, Rochebr.,	254
vermicularis (*Rüpp.*),	254
Doratosepion, Rochebr.,	230
trygoninum, Rochebr.,	233
Dosidicus, *Stp.*,	244

	Page
Dosidicus—*continued.*	
eschrichtii, *Stp.*,	244
steenstrupii, *Pfir.*,	244
Dyctydiopsis, Rochebr.,	257
ellipsoptera (Ad. et Rv.),	258
Eledone, *Leach*,	223
aldrovandi, Macgill.,	224
aldrovandi (Raf.),	224
brevis, *Hoyle*,	224
cirrosa (*Lmk.*),	224
genei, Vér.,	224
halliana, *Rochebr.*,	224
moschata (*Lmk.*),	223
pennantii, Macgill.,	224
rotunda, *Hoyle*,	224
verrucosa, *Vll.*,	224
Eledonella, *Vll.*,	225
diaphana, *Hoyle*,	225
pygmæa, *Vll.*,	225
Eledonenta, *Rochebr.*,	225
filholiana, *Rochebr.*,	225
microsicya, *Rochebr.*,	225
Enoploteuthis, *d'Orb.*,	247
armata (Q. et G.),	248
cookii, Owen,	248
hoylei, *Pfir.*,	248
leptura (*Leach*),	247
lesueurii, d'Orb. et Fér.,	248
margaritifera, Rüpp.,	247
owenii, Vér.,	249
pallida, *Pfir.*,	248
polyonyx, Trosch.,	249
smithii, Gray,	247
veranyi, Rüpp.,	249
Entomopsis, Rochebr.,	246
clouei, Rochebr.,	246

	Page
Hoylea—*continued.*	
sepioidea (*Val.*),	224
Hyaloteuthidæ, Pfir.,	255
Hyaloteuthis, Pfir.,	254
vermicularis, Pfir.,	255
IDIOSEPII, *Stp.*,	229
Idiosepius, *Stp.*,	229
pygmæus, *Stp.*,	229
Illex, *Stp.*,	245
coindetii (*Vér.*), 244,	245
illecebrosus (*Lesr.*),	245
Inioteuthis, *Vll.*,	227
japonica (*Vll.*),	227
morsei, *Vll.*,	227
Japetella, *Hoyle*,	225
diaphana, Hoyle,	225
prismatica, *Hoyle*,	225
Leachia, *Lesr.*,	257
borealis, Jeffr.,	252
cyclura, *Lesr.*,	257
dubia (*Rathke*),	258
ellipsoptera (*Ad. et Rv.*),	258
hyperborea, Stp.,	256
reinhardtii, Stp.,	256
Leptoteuthis, Vll.,	254
diaphana, Vll.,	255
vermicolaris (Rüpp.),	255
Lestoteuthis, Vll.,	252
fabricii (Licht.),	253
kamtschatica (Middf.),	252
Liocranchia, *Pfir.*,	256
brockii, Pfir.,	256
reinhardtii (Stp.),	256
Lioglossa, *Ltk.*,	211
LOLIGINEI, *Stp.*,	236
Loliginis *species max-*	

Loligo—*continued.*	
duvaucelii, *d'Orb.*,	
eblanæ, Ball,	
edulis, *Hoyle*,	
ellipsura, *Hoyle*,	
emmakina, *Gray*,	
forbesii, *Stp.*,	
gahi, *d'Orb.*,	
galatheæ, *Stp.*,	
gronovii, *Fér.*,	
hardwickei, *Gray*,	
hemiptera, *Howell*,	
illecebrosa, Lesr.,	
indica, *Pfir.*,	
japonica, *Stp.*,	
kobiensis, *Hoyle*,	
lanceolata, *Raf.*,	
laticeps, Owen,	
lepturo, Leach,	
macrophthalma, *Laf.*,	
magna, Ad.,	
marmoræ, Vér.,	
media (*L.*),	
mediterranea, Targ.,	
meneghini, Vér.,	
microcephala, *Laf.*,	
moulinsi, *Laf.*,	
neglecta, Gray,	
odogadium, *Raf.*,	
oualaniensis, Less.,	
parva, d'Orb.,	
patagonica, *E. A. Sm.*,	
pavo, Lesr.,	
pealei, *Lesr.*,	
pfefferi, *Hoyle*,	
pillæ, Vér.,	

Stanford University Libraries

Loligopsis—*continued.* Page
bomplandi, Vér., . 253
ellipsoptera, Ad. et Rv., 258
guttata, Grant, . 257
ocellata, Owen, . 254
pavo (Lesr.), . . 256
peronii, *Lmk.*, . 229, 258
schneehagenii, Pfr., . 257
veranyi, Fér., . . 253
vermicularis, Rüpp., 254
zygæna, *Vér.*, . . 258
Loliolus, *Stp.*, . . 241
affinis, *Stp.*, . . 241
steenstrupi, *Dall*, . 241
typus, *Stp.*, . . 241
Lolliguncula, *Stp.*, . 241
brevis (*Blv.*), . . 241
Lophosepion, Rochebr., 230
MASTIGOTEUTHIDÆ, *Vll.* 247
Mastigoteuthis, *Vll.*, 247
agassizii, *Vll.*, . . 247
Megalocranchia, Pfr., 256
maxima, Pfr., . . 257
Megaloteuthis, Kent, . 245
harveyi, Kent, . . 245
Megateuthus, Hilg.
martensii, Hilg., . 246
Metasepia, *Hoyle*, . 234
pfefferi, *Hoyle*, . 234
tullbergi (*App.*), . 234
Moroteuthis, . . 250
robusta, Vll., . . 251
Mouchezia, *Vélain*, . 246
sancti-pauli, *Vélain*, 246
Myopsida, *d'Orb.*, . 225
NAUTILIDÆ, *Owen*, . 258
Nautilus, *L.*, . . 258
macromphalus, *Sow.*, 259
pompilius, *L.*, . . 258
scrobiculatus, *Soland.*, 259
stenomphalus, *Sow.*, 259
umbilicatus, *Lister*, . 259
Nectoteuthis, *Vll.*, . 227
pourtalesii, *Vll.*, . 227
Octopidæ, d'Orb., . 215
OCTOPODA, *Leach*, . 211
OCTOPODIDÆ, *d'Orb.*, . 215
Octopodoteuthis, Krohn et Rüpp., . } 249
sicula (Rüpp.), . 249
Octopoteuthis, Rüpp.
sicula, Rüpp., . . 249
Octopus, *Lmk.*, . . 215
aculeatus, *d'Orb.*, . 218
ægina, *Gray*, . . 221
alderii, *Vér.*, . . 220
aranea, *d'Orb.*, . . 219
arcticus, *Prosch*, . 219
areolatus, *de Haan*, . 217
argus, Krauss, . . 218
australis, *Hoyle*, . 217

Octopus—*continued.* Page
bairdii, Vll., . . 219
bandensis, *Hoyle*, . 220
berenice, *Gray*, . 221
bermudensis, *Hoyle*, 220
bimaculatus, *Vll.*, . 217
boscii (*Lesr.*), . . 216
var. *pallida*, Hoyle, 216
brevipes, *d'Orb.*, . 221
breviten taculatus, Blv., 216
cærulescens, *Péron*, . 222
capensis, *E. et S.*, . 221
carena, Vér., . 213, 214
carolinensis, *Vll.*, . 217
cassiopea, *Gray*, . 221
catenulatus, Fér., 213, 214
cephea, *Gray*, . . 221
cirrhosus, Lmk., . 224
cocco, Vér., . . 223
communis, *Park*, . 221
cordiformis, Q. et G., 222
cornutus (*Owen*), . 222
cuvieri, d'Orb., . 220
cyanea, *Gray*, . . 221
de filippi, *Vér.*, . 217
didynamus, *Raf.*, . 222
dubius, E. et S., . 215
duplex, *Hoyle*, . 218
eudora, *Gray*, . . 221
fang-siao, *d'Orb.*, . 222
favonia, *Gray*, . . 221
filosus, *Howell*, . 220
fimbriatus, *Rüpp.*, . 222
fontanianus, *d'Orb.*, . 218
frayedus, *Raf.*, . 222
furvus, *Gld.*, . . 218
geryonea, *Gray*, . 221
globosus, *App.*, . 218
gracilis, E. et S., . 214
gracilis, *Vll.*, . . 220
granosus, *Blv.*, . 222
granulatus, *Lmk.*, . 216
hardwickei, *Gray*, . 221
harmandi, *Rochebr.*, . 222
hawaiensis, *E. et S.*, 218
heteropus, *Raf.*, . 222
honkongensis, Stp., . 220
horridus, *d'Orb.*, . 217
hyalinus, Rang, . 215
incertus, Targ., . 216
indicus, Rapp., . 223
januarii, *Stp.*, . . 220
koellikeri, Vér., . 215
lentus, *Vll.*, . . 218
levis, *Hoyle*, . . 220
longipes, *Leach*, . 222
lunulatus, *Q. et G.*, . 219
macropus, *Risso*, . 220
maculosus, Hoyle, . 219
maorum, *Hutton*, . 221
marmoratus, *Hoyle*, . 217

Octopus—*continued.* Page
medoria, *Gray*, . 221
megalocyathus, *Gld.*, 218
megalocyathus, Phil., 218
membranaceus, *Q. et G.*, 217
microstomus, Reyn., . 215
mimus, *Gld.*, . . 221
mollis, *Gld.*, . . 221
moschatus, Lmk., . 223
obesus, *Vll.*, . . 218
occidentalis, *Stp.*, . 216
ocellatus, Gray, . 217
ornatus, *Gld.*, . . 220
peronii (*Lesr.*), . . 222
(*Philonexis*) *atlanticus*, d'Orb., . . } 214
(*Philonexis*) *quoyanus*, d'Orb., . } 214
pictus, *Brock*, . . 219
var. fasciata, Hoyle, 219
pictus, Vll., . . 219
pilosus, *Risso*, . . 222
piscatorum, *Vll.*, . 218
polyzenia, *Gray*, . 217
punctatus, *Gabb*, . 220
pusillus, *Gld.*, . . 221
rugosus, Bosc, . . 216
salutii, *Vér.*, . . 216
saphenia, *Gray*, . 221
semipalmatus, Owen, 215
sinensis, d'Orb., . 217
superciliosus, *Q. et G.*, 217
tehuelchus, *d'Orb.*, . 218
tenebricus, *E. A. Sm.*, 218
tetracirrhus, d. Ch., 223
tetradynamus, *Raf.*, 222
tetricus, *Gld.*, . . 216
tonganus, *Hoyle*, . 217
troscheli, Targ., . 216
tuberculatus, *Blv.*, . 216
tuberculatus, Risso, . 213
unicirrhus, d. Ch., . 223
variolatus, Blv., . 216
velatus, Rang, . . 214
velifer, Fér., . . 214
ventricosus, Grant, . 224
verrilli, *Hoyle*, . 219
verrucosus, *Hoyle*, . 216
vitiensis, *Hoyle*, . 217
vulgaris, *Lmk.*, 215, 223
var. *americanus*, d'Orb. 216
Ocythoë, *Raf.*, . . 213
Ocythoë, Leach et Auctt., 212
tuberculata, *Raf.*, . 213
ŒGOPSIDA, *d'Orb.*, . 242
Ommastrephes, *d'Orb.*, 242
æquipodus, *Rüpp.*, . 244
arabicus (Ehrbg.), . 241
ayresii, Gabb, . . 243
bartramii (*Lesr.*), . 242
crassus, *Laf.*, . . 244

	Page
Ommastrephes—*continued.*	
cylindricus, d'Orb.,	242
eblanæ (*Ball*),	243
ensifer, Owen,	243
gigas, *d'Orb.*,	242
illecebrosa, d'Orb.,	245
insignis, *Gld.*,	244
megapterus (*Vll.*),	243
oualaniensis (*Less.*),	243
pacificus (Stp.),	244
pelagicus (*Bosc*),	243
peratoptera, d'Orb.,	252
pteropus, *Stp.*,	242
robustus, Dall,	251
sagittatus, d'Orb.,	245
sloanii, Gray,	244
todarus, d'Orb.,	244
tryonii, Gabb,	243
OMMASTREPHIDÆ, *Gill*,	242
OMMASTREPHINI, *Stp.*,	242
Ommatostrephes. *See* Ommastrephes.	
Onychia, Lesr.,	251
angulata, Lesr.,	250
binotata, Pfir.,	251
cardioptera (d'Orb.),	251
carribæa, Lesr.,	251
curta, Pfir.,	252
krohnii (Vér.),	252
meneghini (Vér.),	252
ONYCHII, *Stp.*,	247
ONYCHOTEUTHIDÆ, *Gray*,	247
Onychoteuthis, *Licht.*,	249
æquimanus, *Gabb*,	250
amæna, Möller,	252
armatus, Q. et G.,	248

	Page
Onychoteuthis—*continued.*	
raptor, *Owen*,	250
robusta, Dall,	251
rutilus, *Gld.*,	250
Onykia *angulata*,	250
Opisthoteuthis, *Vll.*,	212
agassizii, *Vll.*,	212
Owenia, Prosch,	252
Ozoena, Raf.,	223
aldrovandi, Raf.,	224
Parasira, Stp.,	213
catenulata (Fér.),	214
tuberculata, Targ.,	214
Perothis, Rathke,	257
dubia, Rathke,	258
dussumieri, Rochebr.,	258
escholtzii, Rathke,	257
pellucida, Rathke,	257
Phasmatopsis, Rochebr.,	256
cymoctypus, Rochebr.,	257
PHILONEXIDÆ, *d'Orb.*,	214
Philonexis, d'Orb.,	214
atlanticus, d'Orb.,	214
dubia, Vér.,	215
eylais, d'Orb.,	255
hyalinus, d'Orb.,	215
microstomus, d'Orb.,	215
quoyanus, d'Orb.,	214
tuberculatus, d'Orb.,	214
velifer (Fér.),	214
Pinnoctopus, *d'Orb.*,	222
cordiformis (*Q. et G.*),	222
Plectoteuthis, Owen.	
grandis, Owen,	246
Procalistes, Lankester,	256
suhmii, Lankester,	257
Promachoteuthis, *Hoyle*,	229

	Page
Rossia—*continued.*	
papillifera, Jeffr.,	228
patagonica, *E. A. Sm.*,	228
sublevis, *Vll.*,	228
tenera (*Vll.*),	228
Scæurgus, *Trosch.*,	223
coccoi, Trosch.,	223
tetracirrhus (*d. Ch.*),	223
titanotus, *Trosch.*,	223
unicirrus (*d. Ch.*),	223
Sciadephorus, Reinh. et Pr.,	211
mülleri, Reinh. et Pr.,	211
Sepia, *L.*,	230
aculeata, *v. Hass.*,	232
affinis, E. et S.,	235
andreana, *Stp.*,	233
andreanoides, *Hoyle*,	233
antillarum, *d'Orb.*,	235
apama, *Gray*,	234
australis, *d'Orb.*,	232
australis, Q. et G.,	233
bertheloti, *d'Orb.*,	231
bilineata, Q. et G.,	237
bisserialis, Mont.,	233
boscii, Les.,	216
brachycheira, *Tapp.-Can.*,	234
brevimana, *Stp.*,	232
capensis, *d'Orb.*,	233
carunculata, Sehn.,	253
cultrata, *Stp.*,	232
elegans, *d'Orb.*,	233
elliptica, *Hoyle*,	232
elongata, *d'Orb.*,	233
enoplon (*Rochebr.*),	235
esculenta, *Hoyle*,	232

Stanford University Libraries

Page

Sepia—*continued.*
myrsus, *Gray*, . 230
octopodia, Pennt., . 224
oculifera (*Rochebr.*), . 235
officinalis, Aud., . 231
officinalis, *L.*, . . 230
orbignyana, *Fér.*, . 232
ornata, Rang, . . 235
pagenstecheri, *Pfft.*, 231
palmata (*Owen*), . 234
papillata, Q. et G., . 234
papuensis, *Hoyle*, . 231
pelagica, Bosc, . . 243
peronii, Lesr., . . 222
peterseni, *App.*, . 233
pfefferi, *Hoyle*, . . 234
pharaonis, Ehrbg., . 232
plangon, *Gray*, . 231
polynesica, *Pfft.*, . 231
recurvirostra, *Stp.*, . 233
rostrata, *d'Orb.*, . 232
rouxii, *d'Orb.*, . . 232
rugosa, Bosc, . . 216
ruppellaria, *d'Orb.*, . 233
savignyi, *Blv.*, . 231
sinensis, d'Orb., . 235
singaporensis, *Pfft.*, . 231
sinope, Gray, . . 233
smithi, *Hoyle*, . . 231
sulcata, *Hoyle*, . 233
tourrannensis, E. et S., 235
trygonina (*Rochebr.*), 232
tuberculata, *Lmk.*, . 234
tullbergi, *App.*, . 234
unguiculata, Molina, 248
venusta, *Pfft.*, . . 232
vermiculata, *Q. et G.*, 231
verreauxi (*Rochebr.*), 231
vicellius, *Gray*, . 231
zanzibarica, *Pfft.*, . 232
Sepidæ, d'Orb., . . 229
SEPIADARII, *Stp.*, . 229
Sepiadarium, *Stp.*, . 229
kochii, *Stp.*, . . 229
SEPIARII, *Stp.*, . . 229
Sepiella, *Gray*, . . 235
affinis (*E. et S.*), . 235
curta, *Pfft.*, . . 235
dabryi (*Rochebr.*), . 236
inermis (*v. Hass.*), . 235
maindroni, *Rochebr.*, 236
martini (*Rochebr.*), . 236
obtusata, *Pfft.*, . 235
ocellata, *Pfft.*, . . 235
ornata (*Rang*), . . 235
ovata (*Pfft.*), . . 235
tourrannensis (*E. et S.*), 235

Page

Sepiola, *Leach*, . . 225
atlantica, *d'Orb.*, . 226
bursa, Pfft., . . 227
dispar, Rüpp., . . 229
japonica, Til., . . 227
leucoptera, Vll., . 227
lineolata, Q. et G., . 229
macrosoma, d. Ch., . 227
major, Targ., . . 226
oceanica, d'Orb., . 226
oweniana, *d'Orb.*, . 226
pacifica, *Kirk*, . . 226
penares (*Gray*), . 226
pusilla, *Pfft.*, . . 226
rondeleti, *Leach*, . 225
rossiæformis, *Pfft.*, . 226
schneehageni, *Pfft.*, . 226
stenodactyla, *Grant*, 226
subalata, Gerv. et v. Ben., . . . 240
tasmanica, *Pfft.*, . 226
SEPIOLINI, *Stp.*, . 225
Sepioloidea, *d'Orb.*, . 229
lineolata (*Q. et G.*), . 229
Sepioteuthis, *Blv.*, . 236
arctipinnis, *Gld.*, . 238
australis, *Q. et G.*, . 236
bilineata (*Q. et G.*), . 237
blainvilliana, *Fér.*, . 236
brevis, *Owen*, . . 237
ehrhardti, *Pfft.*, . 236
guinensis, Q. et G., . 236
hemprichii, Ehrbg., . 237
lessoniana, *Fér.*, . 237
loliginiformis (*Lkt.*), 237
lunulata, *Q. et G.*, . 236
madagascariensis, *Gray*, . . . 237
major, *Gray*, . . 237
mauritiana, *Q. et G.*, 236
neoguinaica, *Pfft.*, . 237
ovata, *Gabb*, . . 237
sepioidea (*Blv.*), . 236
sicula, Rüpp., . . 242
sinensis, *d'Orb.*, . 237
sloanii, *Leach*, . . 237
Spathidosepion, Rochebr. 230
Spirula, *Lmk.*, . . 230
peronii, *Lmk.*, . . 230
Stauroteuthis, *Vll.*, . 211
syrtensis, *Vll.*, . 211
Steenstrupiola, *Pfft.*, 247
atlantica, *Pfft.*, . 247
chilensis, *Pfft.*, . 247
Sthenoteuthis, Vll., . 242
megaptera, Vll., . 243
pteropus (Vll.), . 243

Page

Stoloteuthis, *Vll.*, . 227
leucoptera, *Vll.*, . 227
Taonius, *Stp.*, . . 256
cymoctypus (*Rochebr.*), 257
elongatus, *Stp.*, . 257
hyperboreus, *Stp.*, . 256
maximus (*Pfft.*), . 257
pavo (*Lesr.*), . . 256
schneehageni (*Pfft.*), 257
suhmi (*Lankester*), . 257
TAONOTEUTHI, *Stp.*, . 253
Teleoteuthis, *Vll.*, . 251
agilis, *Vll.*, . . 252
caribbæa (*Lesr.*), . 251
curta (*Pfft.*), . . 252
krohnii (*Vér.*), . 252
meneghini (*Vér.*), . 252
peratoptera (*d'Orb.*), 252
platyptera (*d'Orb.*), . 251
TETRABRANCHIATA, *Owen*, . . . 258
Teuthis, Gray.
parva, Gray, . . 240
THYSANOTEUTHIDÆ, *Kef.* 242
Thysanoteuthis, *Trosch.*, 242
elegans, *Trosch.*, . 242
rhombus, *Trosch.*, 237, 242
Todarodes, *Stp.*, . 244
pacificus, *Stp.*, . 244
sagittatus (*Lmk.*), . 244
sloanii (*Gray*), . . 244
Tracheloteuthis, *Stp.*, 246
behnii, *Stp.*, . . 246
clouei (*Rochebr.*), . 246
riisei, *Stp.*, . . 246
velaini (*Rochebr.*), . 246
TRACHYGLOSSA, *Ltk.*, . 212
Tremoctopus, *d. Ch.*, . 214
atlanticus (*d'Orb.*), . 214
dubius (*E. et S.*), . 215
gracilis (*E. et S.*), . 214
hyalinus (*Rang*), . 215
microstomus (*Reyn.*), 215
ocellatus, *Brock*, . 215
quoyanus (*d'Orb.*), . 214
semipalmatus (*Owen*), 215
velifer (Fér.), . . 214
violaceus, *d. Ch.*, . 214
Tritaxeopus, Owen, . 222
cornutus, Owen, . 222
Verania, *Krohn*, . 249
sicula, *Krohn*, . . 249
Verrilliola, Pfft., . 246
gracilis, Pfft., . . 246
nympha, Pfft., . . 246
Zygænopsis, Rochebr., 258
zygæna, Rochebr., . 258

XIX. *Observations on Cyclopea in the Human Subject and in the Lower Animals.* By J. Symington, Esq., M.D., F.R.S.E., and G. Sims Woodhead, Esq., M.D., F.R.S.E.

(Read 21st April 1886.)

Cyclopea, although comparatively rare in the human subject, is by no means of uncommon occurrence amongst mammals, but seems to be rare in birds. The degree of malformation varies very considerably, even in the same species, but it preserves a comparative uniformity in all mammals, as can readily be explained by the similarity in the general mode of development of the face, brain, and cranium.

The most recent and elaborate contribution to the subject of cyclopean monsters is by Professor Hannover of Copenhagen,[1] who holds that we must look for the cause of this condition in an incomplete development of the anterior part of the primordial cartilage of the base of the skull, and we must not consider it as merely an arrest of development. He further points out that in man cyclopea is frequently associated with hydrocephalus, more rarely with anencephalus, and often with deformities of various kinds, such as

Stanford University Libraries

the skull of a cyclopean lamb, which he allowed us to examine, was only one of a large number of similar monsters begotten by the same ram.

In the human subject cyclopea appears to be commoner amongst females than in males, 55 of those mentioned by Hannover being females and 16 males; in the other cases the sex was not recorded. As a rule these monsters are born between the sixth and eighth month of gestation. They seldom breathe after birth, although in a few cases life appears to have been prolonged for a few hours.

We have based our observations on the following specimens to which we have had access; the more important of these we will briefly describe.

(*a.*) *Human Cyclops.*—This occurred in the practice of Dr William Craig, of Edinburgh, to whom we are indebted for the opportunity of making a complete dissection.

The specimen was a well-nourished male fœtus. It was 19 inches in length, had an ossific centre in the lower extremity of each femur, and, in fact, presented the usual indications of having been born at the full time. In addition to the cyclopean malformation this fœtus presented several minor abnormalities. There were six toes on each foot, but the supernumerary one on the right side was very small. The external genitals exhibited a slight tendency to resemble in appearance those of the female, for the fold of integument forming the scrotum passed upwards and inwards, so as to meet in front of the pubes in a somewhat similar manner to that in which the labia majora unite to form the mons veneris. The penis was small, and almost concealed by the above-mentioned fold. The left testicle had descended into the scrotum, but the right one was still in the abdomen.

The upper part of the head was smaller than normal, and presented a constriction just above the level of the pinnæ of the ears. In the middle line below the forehead was situated a freely movable snout or proboscis. This was about an inch in length, and was traversed in its whole extent by a single canal, which terminated in front by an opening at its free extremity. Below the snout there was a small lozenge-

shaped space, the lateral angles of which were continuous with fissures running outwards between the eyelids. The floor of this space was of a reddish colour, and appeared to be formed by mucous membrane, but there were no indications of an eye.

Plate xlvii., fig. 3, of Ahlfeld's *Missbildungen des Menschen*, shows a specimen in which the external appearances were very similar to those in this case. Unfortunately the brain was very soft, so that its exact condition could not be accurately determined; but there was evidently only one cerebral hemisphere, and no indications of a longitudinal fissure. We could find no traces of the olfactory nerve, and there were only a single optic nerve and foramen, but all the other cranial nerves were present. In the dissection of this specimen special attention was directed to the condition of the bones of the skull and the formation of the orbital and nasal cavities. A few of the bones were apparently absent, some considerably altered in shape, and even those of normal configuration were smaller than usual.

The occipital bone consisted of four pieces—a basi-occipital, two ex-occipitals, and a supra-occipital; the latter was inclined more nearly vertical than usual. The squamoso-zygomatic and petromastoid parts of the temporal bone were firmly united together; they were very small, and rather

Oxford University Libraries

A thin bar of cartilage extended forwards, in the middle line, from the post-sphenoid above the optic foramen to the root of the snout. At the upper part of the base of the snout two rudimentary nasal bones were found. They articulated with the frontal.

As already mentioned, the snout contained a single canal. On dividing the snout close to its base the canal was seen to communicate with two rudimentary nasal cavities. These cavities were surrounded, except in front and above, by a bony capsule. Their roof was formed by the thin bar of cartilage already mentioned, and the dura mater which was perforated by several small holes. The bone, with the dura mater and cartilage, formed a rounded capsule, which was little more than half an inch in diameter. On vertical transverse section it was seen to contain a mesial septum and two lateral cavities. The septum was well defined, and reached to the floor of the cavity, but was not united with it. The outer wall of each cavity contained some irregular spaces, which might be regarded as rudimentary ethmoidal sinuses. The septum, as well as the outer walls of the nasal cavities, was well ossified. The two superior maxillary bones were firmly united with one another, and both of them were devoid of nasal processes. There were no indications of pre-maxillary bones, and their absence was confirmed by an examination of the teeth as there were no incisors, each superior maxilla containing only three milk teeth—a canine and two molars. Behind the superior maxillary bones were found the palates, which were united with one another and with the maxillary bones. They were considerably altered in shape, and besides forming part of the hard palate, they extended upwards behind the bodies of the superior maxillæ to form the posterior part of the floor of the orbital cavity. The malars were normal, but no traces of the vomer or lachrymals could be found. The two halves of the lower jaw were separable, and contained the normal number of teeth. The single orbital cavity was bounded above by the frontal, below by the superior maxillæ and palates, and on each side by the malar and great wing of the sphenoid.

The optic nerve divided soon after entering the orbit into two branches, which were connected with two rudimentary eyeballs. The sclerotic and choroid of each eye were distinct, but the cornea, pupil, and lens could not be detected.

The part of the pharynx lying above the level of the soft palate reached as usual to the lower surface of the basisphenoid, but anteriorly it was bounded by the united palates, and there were no posterior nares.

(*b.*) *Cyclopean Fœtus of Pig.*—For this fœtus we are indebted to Dr Munro, jun., of Ratho. It was one of a large litter, and was dead when found. The others were normal and healthy. Its external appearance was more distinctly cyclopean than that of the human subject already described, for below the proboscis there was a large and prominent eyeball. The proboscis had a firm bony base projecting nearly an inch beyond the frontal bone, and it terminated in a movable fleshy portion, half an inch in length. The trunk bent downwards over the middle of the front of the eyeball, and at its free extremity there was an orifice leading into a canal in its interior. The eyeball extended considerably in front of the eyelids, which were small. The only indications of an incomplete fusion of the two eyeballs were two slight projections of the sclerotic into the cornea, one above and

Cleveland University Libraries

of the snout, and gradually increased in size as it passed backwards.

In this was a peculiar septum, which also increased in both size and complexity as it passed backwards. It was composed almost entirely of mucous membrane, and was somewhat T shaped; the vertical limb was continuous with the floor of the cavity, and the two lateral limbs were so folded downwards that they appeared almost like the membrane covering the turbinated bones. The canal, after increasing in size, passed to the base of the "trunk," where it terminated in a blind bony extremity.

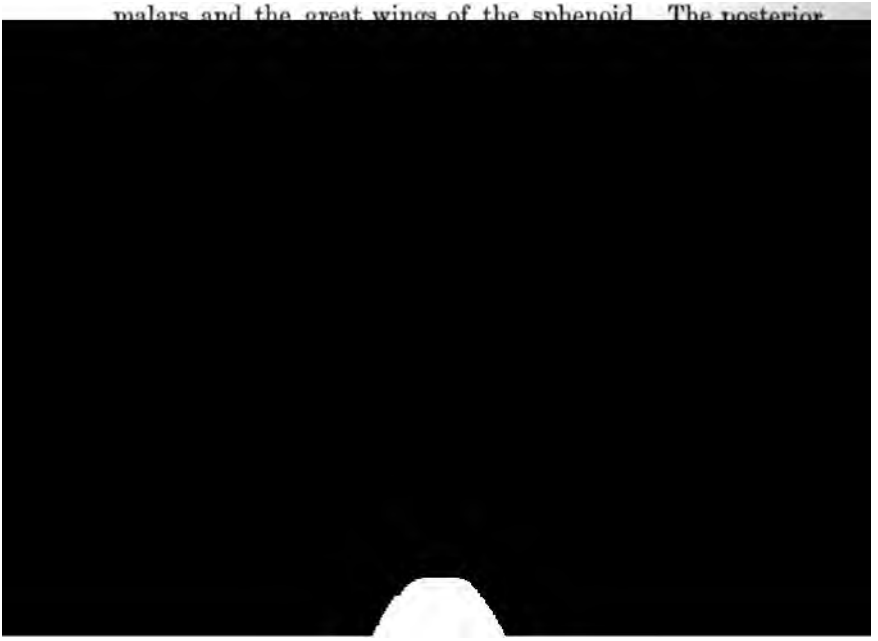
On making a transverse section through the eyeball about midway between its anterior and posterior extremities, the sclerotic and choroid coats could be made out with perfect distinctness, but there was not the slightest trace of a retina or nervous elements.

The cavity was filled with a reddish brown coagulum, which appeared to be blood. On examining the posterior aspect of the anterior section of the eye, no trace of the partial division observed from without could be seen. The globe was perfectly simple, and had no septum of any kind. Nothing could be found to represent a lens. A single pigmented band surrounding the pupil very irregularly was all that was to be seen of an iris. When first seen the cornea was quite transparent. In the posterior half, as mentioned above, there is no retina.

The alterations in the bones of the skull were very similar to those of the human fœtus already described. The two lateral portions of the pre-sphenoid had united in the middle line, leaving a small foramen, which apparently represented the optic foramen. It was occupied simply by fibrous tissue, in which there were no nervous strands, the optic nerve being quite absent. Immediately around the anterior or orbital aspect of this foramen the bone afforded attachment to a number of muscular fibres—the muscles of the eyeball. The two sphenoidal fissures were of large size. The body of the post-sphenoid was firmly ossified to the great wings, and the whole of these parts were smaller than normal. The two temporal bones were somewhat irregular in shape, and

owing to the smallness of the basi-occipital and basi-sphenoid, they were nearer together than normal.

On removing the mucous membrane from the hard palate the two superior maxillary bones were found to be firmly united in the mesial plane, there being no indications of intermaxillary bones. The teeth, which have erupted, were three in number, one central and two lateral. The central tooth was not embedded in the superior maxillary bone, but in the mucous membrane in front of this bone. The two lateral teeth had the appearance of canines. The horizontal plates of the palate bones met in the middle line, and the soft palate was perfectly normal; on reflecting the latter to expose the upper part of the pharynx, this cavity was found to be normal in many respects, the Eustachian orifices and the fossæ behind them having their normal position and relations. It was found, however, that there were no indications of openings in the anterior wall. On reflecting the mucous membrane from this anterior wall, the pharynx was seen to be bounded in front by bone, derived from the vertical plates of the palate bone and from the internal pterygoid plates. The single orbital cavity was single, and was limited above by the frontal bone, below by the superior maxillary and malar bones, and externally by the malars and the great wings of the sphenoid. The posterior



Stanford University Libraries

passing across the horizontal oval. (*e.*) A puppy, in which also the proboscis is above the eye, as in the case of the pigs, and in other respects very similar to the above. (*f.*) A kitten, with one eye, in which there are two well-formed pupils; here also the proboscis comes from the forehead. (*g.*) A very young fœtus (calf?), in which there is but a single eye, with one pupil and one cornea. At the junction of the ocular and palpebral conjunctivæ there is a deep fold, and the eye is smaller than in most of the other specimens. There is no proboscis, and the upper jaw below the eye is much depressed. The tongue is very much protruded.

(*h.*) Cyclopean lamb, in which there is a single eye, with a partial division of the pupil; the upper jaw is characterised by the same depression that is found in the calf (?). In it there are no teeth, but simply a series of rough papillæ. The investing skin and mucous membrane extends for some considerable distance beyond the bone. In the lower jaw, which also protrudes somewhat, there are six teeth already erupted.

(*i.*) Skull of cyclops puppy. In this the occipital, parietal, temporal, and malar bones are all normal. The frontal bones are fused together, and there are no traces of nasal bones in this macerated skull. The two superior maxillary bones are firmly fused, and there are no traces of pre-maxillary bones. There are three teeth in the upper jaw—two lateral teeth, corresponding in position and appearance to canines, and a central tooth, the fang of which is not imbedded in the superior maxillary bone, but lies in front of the alveolar arch. It is, however, supported by two small spicules of bone, which pass forwards, one on each side. They do not reach to the front of the fang, where the tooth is covered by mucous membrane only. The palate bones are fused in the median line, but not ossified to the superior maxillæ. The vertical plates of the palate bones are fused and twisted so as to present anterior and posterior surfaces. These, with the internal pterygoid processes, form the anterior wall of the naso-pharynx, which extends forwards for some little distance above the horizontal plates of the palate bones. There are no indications of posterior nares at the bottom of this de-

pression, with the exception of a single small mesial canal which ends blindly. The orbit is a single cavity, in which, however, there are indications of an incomplete septum. Thus there were two supra-orbital ridges connected with the frontal bone, and from the middle line there is a slight ridge in the roof, which extends as far back as the optic foramen; and the latter, though single, has a spicule of bone extending part way across. Each half of the superior maxillary bone presents a concave border at the anterior part of the floor of the orbit, and in the middle line between them is a slight prominence.

(*j.*) Skull of sheep (kindly lent by Mr Brotherston, curator of the Kelso Museum), to which reference has already been made. The occipital, parietal, and temporal bones are all normal; the two portions of the frontal bone are firmly united in the middle line; the ethmoidal fissures are absent. Here, also, the two orbital plates are fused in the mesial plane. The two halves of the pre-sphenoid are united, and surround a single large optic foramen. The post-sphenoid is normal in shape, but the body is smaller than normal. The cranial cavity is well developed, and of considerable size. The superior maxillary bones are fused; neither nasal processes nor nasal bones are present. The pre-maxillaries are

Stanford University Libraries

central position. The term Cyclopea is not, however, free from objection, for the existence of a single eye is by no means constant, as the group includes monsters in which there are two distinct eyeballs, and others in which both are absent. The Cyclopea embrace all those monsters in which there is defective development of the parts derived from the anterior cerebral vesicle, so that the fore-brain is not divisible into two hemispheres, the olfactory bulbs are absent or rudimentary, and the optic vesicles are more or less imperfectly divided, or even in extreme cases entirely absent. Associated with the cerebral defects are changes in the nasal and orbital cavities, the latter tending to unite more or less completely into a single orbit, and the former to be pushed upwards and forwards, and prevented from forming any communication with the pharynx.

Many writers maintain that we must seek for the primary cause of these malformations in the defective development of the anterior cerebral vesicle; while Hannover seems disposed to regard an imperfect formation of the prechordial part of the base of the skull as the primary defect. There can be no doubt that the malformations of these two parts—brain and skull—are intimately connected with one another. We will briefly refer to several points of interest suggested by our examination of the condition of the skull bones. In all our specimens the orbital cavity was single, although in a few cases it presented faint indications of a mesial septum. The proboscis, which usually exists, and is placed above the orbit, is formed from the fronto-nasal process and the lateral nasal processes. The cavity in its interior in the human subject (*a.*), and in the pig (*b.*), evidently represented imperfect nasal cavities. In consequence of the fusion of the two orbits, these always terminate behind blindly, and never communicate with the pharynx.

Normally the fronto-nasal process descends to form the columella of the nose, and below that it gives rise to the lunula or central part of the upper lip. It is interesting, in relation to this point, to notice that in the human cyclops (*a.*) the upper lip did not possess a lunula. In connection with the deeper parts of the fronto-nasal process are formed the

pre-maxillary bones, and in none of our specimens did we find these bones in the alveolar arch. The upper lip and the superior alveolar arch are developed from three processes, viz., the fronto-nasal, which passes down in the middle line, and the maxillary processes, which extend forwards and inwards on each side, and blend with the fronto-nasal. Although the parts developed from the fronto-nasal process are absent, yet there does not appear to be ever a cleft in the middle of the upper lip or superior alveolar arch. Indeed, in the human fœtus, and also in the other specimens, not only did the superior maxillary bones meet in the mesial plane in front, but they were firmly united by bone.

Representatives of the intermaxillary bones do not appear to have been detected in the anterior part of the proboscis. As the incisor teeth are normally found embedded in the intermaxillary bones, their complete absence from the superior alveolar arch, as in the human cyclops (*a.*), is not surprising.

As several of our specimens show, a single central incisor tooth is sometimes found in animals fixed in the gum in front of the superior maxillæ, although the intermaxillary bones are absent. As the teeth are developed from the epiblast lining the mouth and the subjacent mesoblast, the presence of incisor teeth, independent of the presence of a fronto-nasal process and intermaxillary bones, is easily

Dr Ronaldson has recorded in the *Edin. Med. Jour.* (May 1881, p. 1035) a case which bears upon this question. It was that of a child in which there was occlusion of the posterior nares by a firm membrane, and which breathed only when it cried, or had its mouth forcibly opened. It died a few hours after birth from asphyxia. On *post-mortem* examination, this occlusion of the posterior nares was the only pathological condition observed, and Dr Ronaldson attributed the death of the infant to its inability to breathe through the mouth, the normal air passages being at the same time closed. The death of a cyclops is probably due to the same cause.

XX. *Further Notes on the Chemical Composition of Ensilage.*

By W. Ivison Macadam, Esq., F.C.S., F.I.C., etc., Lecturer on Chemistry, School of Medicine, and Professor of Chemistry, New Veterinary College, Edinburgh.

(Read 17th February 1886.)

In my previous communication on this subject,[1] I showed that the proportion of nitrogen found on analysis of the moist ensilage did not represent the albumenoids, for, by drying the sample, a considerable loss of nitrogen was sustained. I therefore proposed that before samples were tested for the true albumenoid nitrogen, they should be first dried so as to expel the volatile ammonia compounds. I further proved that whilst, in many cases, the samples of ensilage as received were acid in character, yet that, not unfrequently, the material was distinctly alkaline. I, therefore, argued that the changes produced by the silage process would be found to consist of—first, a fermentation developing ammonia at the expense of the albumenoids, and secondly, of an acid fermentation; and that according as the conditions under which the grass was placed were more or less favourable to the acid or alkaline decomposition, the resulting product would be found to be acid or alkaline in character.

[1] Vol. viii., p. 477, Proc. Roy. Phy. Soc. Edin.

Since my paper was communicated to this Society (March 18th, 1885), various chemists have published results verifying my figures and conclusions, and amongst these I may refer to the series of articles which have appeared in the *Scottish Agricultural Gazette* by Sir J. B. Lawes, Bart., F.R.S., etc.; by Clifford Richardson, Esq., Assistant Chemist, U.S. Department of Agriculture (*Jour. Chem. Soc.*, vol. xlvii., p. 80); and by Dr A. P. Aitken in his report to the Chemical Department of the Highland and Agricultural Society (*Trans. H. and A. Soc.*, 1885, vol. xvii., p. 397).

Since the date of my previous paper, I have conducted a series of tests and analyses for the purpose of identifying and quantitatively determining the various conditions in which nitrogen exists in the ensilage and also the acids present.

Doubtless the fermentations and decompositions may vary under diverse conditions in the silo, but for the purposes of the present notes, I have confined myself to one somewhat acid sample.

The material had been made from green barley and pease mixed with rye-grass, etc. It was in good condition, and as the various tests had all been carefully considered and laid down previous to the receipt of the sample, no time was given for any further or new actions to be set up, such as

Stanford University Libraries

These results calculated free from the moisture gave:—

ANALYSIS OF ENSILAGE.

(*Moist sample calculated free from moisture.*)

Ether extract,	7·775
Albuminous compounds, etc.,	14·402
Carbohydrates, etc.,	45·949
Woody fibre,	19·478
Ash,	12·394
	99·998
Total nitrogen,	2·304%
Phosphates in ash,	1·499%

After drying a portion, the total nitrogen then found to be present was equal to 1·893 %, showing a loss of nitrogen during the drying process equal to 0·411 % of the dried sample. At this stage of the inquiry, the nitrogen determinations yielded the following results:—

Nitrogen in moist sample,	0·684%
Which calculated to water-free sample is equal to	2·304%
Nitrogen in dried sample,	1·893%
= Albumenoids,	11·831%
Nitrogen lost during drying process,	0·411%
= Ammonia,	0·499%

On distilling a portion of the fresh sample with water, a distillate was obtained which was acid in character. This was considered as proof that no *free* ammonia was contained in the sample, a fact rendered evident by the acid character of the ensilage. The distillate was afterwards treated with sodic carbonate and re-distilled, when a quantity of ammonia was found in the distillate equal to 0·481 % of the original sample. The results for the *volatile* ammonia then stood thus:—

Ammonia = Nitrogen lost on drying original sample,	0·499%
Ammonia = Nitrogen obtained by distillation = volatile ammonia,	0·481%
Ammonia = Volatile nitrogen not accounted for,	0·018%
Containing nitrogen,	0·015%

The residual material left in the retort after the first distillation was found to be still acid, but on treatment with sodic carbonate yielded a distillate containing nitrogen equal

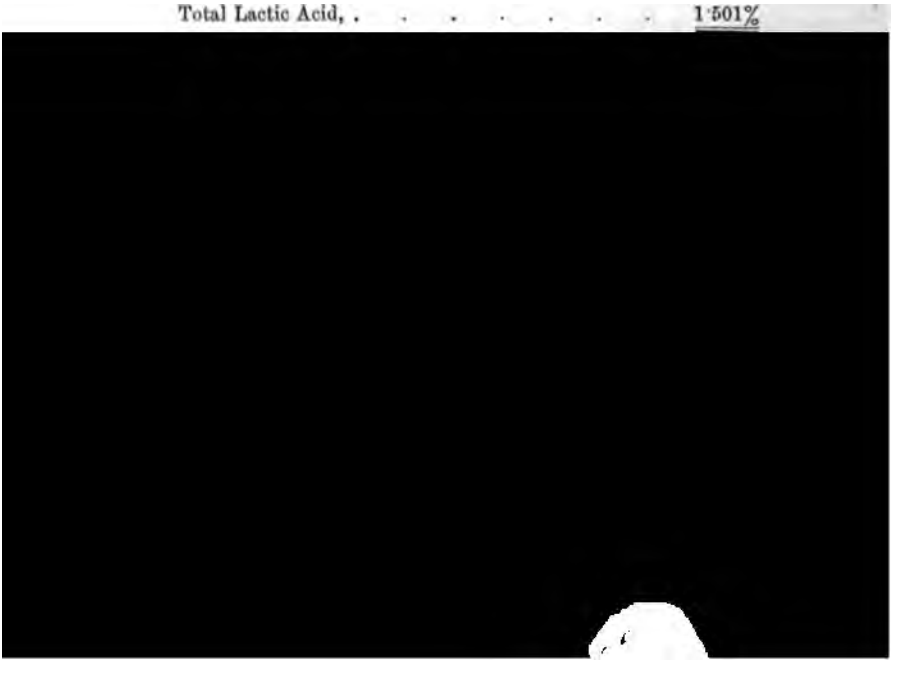
to 0·167 %(=ammonia, 0·202). It thus became evident that no mere process of drying could give satisfactory results of the amount of albumenoid nitrogen, as such figures would be too high from the presence of *fixed* ammonia salts. The nitrogen found during the last-mentioned experiment would be equivalent to 1·044 % of albumenoids, and this deducted from the previously corrected figures leaves 10·787 % as the amount of albuminous material, equivalent to the remaining nitrogen present in the ensilage, after calculating the results as free from moisture.

The volatile acid liquid was found to contain butyric acid, and the acidity present when calculated into that acid gave the following proportions:—

Free (Volatile) Butyric Acid, ...	0·694%
**Combined* ,, ...	2·489%
Total Butyric Acid, ...	3·183%
*=Butyrate of Ammonia, ...	2·970%

The fixed acid contained lactic acid, and the results, when calculated into that acid, gave—

Free (Fixed) Lactic Acid, ...	0·428%
***Combined* ,, ...	1·073%
Total Lactic Acid, ...	1·501%



Stanford University Libraries

The results of the analysis, if calculated on the nitrogen present in the sample after drying, would be—

Ether Extract,	7·776
Albumenoids,	11·831
Carbohydrates, etc.,	48·520
Woody Fibre,	19·479
Ash,	12·394
	100·000

Whilst taking into consideration the various points stated in this paper, the analysis of the material as received would be—

ANALYSIS OF ENSILAGE.

(*As Received.*)

Moisture,	69·224
Ether Extract,	2·226
Albumenoids, etc.,	3·319
Carbohydrates, etc.,	13·748
Woody Fibre,	5·994
Mineral Matter,	3·814
Ammonia Butyrate,	0·914
Butyric Acid (Free),	0·213
Ammonia Lactate,	0·392
Lactic Acid (Free),	0·131
	99·975

These results calculated to the dry material give—

ANALYSIS OF ENSILAGE.

(*Calculated free from Moisture.*)

Ether Extract,	7·347
Albumenoids, etc.,	10·787
Carbohydrates, etc.,	44·672
Woody Fibre,	19·479
Mineral Matter,	12·394
Ammonia Butyrate,	2·970
Butyric Acid (Free),	0·694
Ammonia Lactate,	1·276
Lactic Acid (Free),	0·428
	100·047

Recapitulation.—These results show—

1. That the nitrogen present in the fresh sample does not represent the albumenoids.
2. That nitrogen is present as a volatile combination.
3. That nitrogen is present as a fixed salt.

4. That the acidity is partly volatile, and contains butyric acid.

5. That part of the acidity is non-volatile, and contains lactic acid.

6. That the volatile and fixed acids are in part free and in part in combination with ammonia.

XXI. *Further Notes on North Rona,*[1] *being an Appendix to* Mr JOHN SWINBURNE'S *Paper on that Island in the "Proceedings" of this Society,* 1883-84. By J. A. HARVIE-BROWN, Esq., F.R.S.E., etc. [Plate XI.]

(Read 17th February 1886.)

As an Appendix to the valuable account given to this Society in December 1883 by my friend Mr John Swinburne, I beg to offer, *first*, a drawing of the islands of North Rona and Soulisgeir (or Sula Sgeir) as seen by myself and a friend —Mr Hugh G. Barclay of Norwich—when approaching the former island from the S.E. by S.; and I offer, in the second place, some slight account of our visit to Rona in June of the present year—1886.

I have been able during this visit practically to substantiate most of Mr Swinburne's observations and his accounts of previous writers on the locality, and also to add four

Stanford University Libraries

good representatives of the Danish and Celtic types. Having objections to the appointment of a layman as preacher to the church at Ness, and being grieved at some feeling shown them in consequence of the action which they took along with a few others of the congregation, they were desirous of making some atonement for their opposition, and resolved to leave the place.

"Accordingly, on the morning of Monday, 20th May 1884, they sailed for the island of North Roney, where they landed that night. Ostensibly their reason for going there was to take care of the sheep on the island, but in reality it was to atone for their action against the minister that they went into exile." Mr Carmichael here points out the similarity between the action of these two men voluntarily going into exile, and that of Saint Calum Cille when he left Ireland and went to Scotland. "Twice did boats go out to North Roney—in the following August and September—and the friends endeavoured to get the two men to return to their families and friends, but in vain. The men were then in good health, and apparently enjoyed their island home, and employed themselves in building sheep fanks, fishing, and killing seals." Mr Carmichael here relates a curious instance of a sort of second sight or presentiment of evil regarding the men, which occurred in the person of an old woman called Flora MacDonald residing near Ness, but we need not relate that here, and only mention it in order to point out that, in consequence of her repeated urging upon the people of Ness, strong efforts were made by the relatives to reach Roney. "It was only, however, on the 22d April 1885, after two previous unsuccessful attempts, that they effected a landing. No one met them. At the door of the little half-underground house occupied by the two men the boatmen found the body of Malcolm MacDonald in a sitting position beside an improvised fireplace, as if he had fallen asleep. On the floor of the house, beside the fireplace, lay the body of Murdoch Mackay. His tartan plaid was placed neatly and carefully over and under him, showing that the deft hands and warm heart of Malcolm MacDonald had performed the last sad office to the body of his dead friend. The bodies

were wrapped in canvas wrappings, and buried side by side in the primitive and beautifully situated burial-place adjoining.

"It was feared that the poor men might have met with foul play, and the matter having been brought up in Parliament, the Crown authorities ordered an investigation. Accordingly the procurator-fiscal, Stornoway, and two medical men, proceeded to Roney in the fishing cutter 'Vigilant.' The bodies of the two men were exhumed, and a *post-mortem* examination made. There was no appearance of foul play; it was ascertained that Murdoch Mackay died of acute inflammation of the right lung and left kidney, and that Malcolm MacDonald died from cold, exposure, and exhaustion. The opinion among the friends is that Malcolm MacDonald assiduously attended his friend day and night till he died, by which time he himself became so weak that he could not bury the body, and being unable to remain in the hut had sat down by the improvised fire and died. There was a small pot on the little fireplace at the door, indicating that Malcolm MacDonald meant to prepare for himself some food, which, however, he was never destined to eat. The medical examiners found nothing in his stomach but a few grains of meal and a little brown liquid—probably tea. An abundance of unconsumed food was found in the hut. On this occasion the son of Malcolm MacDonald took two coffins

Stanford University Libraries

accurately dressed, 2 feet long and 1⅛ inch in the side. A notch is neatly cut into the corner of the bar for each day of the week, and then a deeper notch for Sunday, while for the end of the month a cut is made from side to side of the bar. The plan is simple, clever, and intelligible. The markings begin on Friday, the 21st June 1884, and cease on Tuesday, the 17th February 1885. Towards the end the notches are less neatly and accurately made, indicating very clearly that the deft fingers which fashioned the rest were becoming weak and powerless to cut into the hard pine wood. These notches are no less touching than instructive, and speak to the eye and to the heart and the imagination with a pathos all their own. Through a hole in the end of the calendar is a looped cord by which to suspend the stick. It is singular," concludes Mr Carmichael, "if nothing more, that it was about the very time that Flora MacDonald began to see her 'warnings' that the last notch of the stick records the cessation of the last life. These 'warnings' became so all-absorbing to her that she walked fifteen miles to the friends of the exiled men about them;" and Mr Carmichael further relates that he himself interviewed a young man in Edinburgh—Donald Morrison—who was on his way home from Canada to see his people at Ness, and who related that: A fortnight before he had received a letter from Ness saying that the friends of the men in Rona were in a state of extreme anxiety concerning them in consequence of Flora MacDonald's statements; and when the said Donald Morrison landed at Liverpool, he was greatly astonished at the corroboration of Flora MacDonald's fears, or the coincidence, if you will, between her statement and the friends of the men.

I have to thank my friend, Mr J. J. Dalgleish, for a perusal of several letters and copies of MSS. and extracts relating to the island, but as these had already been made full use of by Mr Swinburne, I do not think it necessary to quote from them here again.

The habit of sheep-stealing is still carried on by passing ships or fishermen. In the summer of this year—1885—both sheep and the oil barrels and the plenishings of the house belonging to the dead men, consisting of tea, sugar,

butter, soap, a grinding-stone, etc., were stolen by some Grimsby fishermen, who have since been apprehended. These articles were all upon the island at the time of our visit in June, and there seemed to be considerable honourable feeling even amongst the proprietors against touching the dead men's effects. The Grimsby men were apprehended in their own homes in Grimbsy, taken prisoners to Stornoway, where they were tried before the Sheriff, and sentenced to imprisonment —the crew to two months and the master to eight months. The theft was committed about the end of June, and must have been done within a very short time of the date of our visit in the "Eunice." Another theft of four sheep was committed whilst Malcolm MacDonald and Murdoch Mackay were alive, as reported by them to their friends in August 1884. They could not read the name of the boat, though there was a name on the stern. When in Great Grimsby in December last, the writer of this paper had an interview with a smack owner, in whose employment two of the men apprehended had once been.

The Great Grey Seal (*Halichœrus gryphus*) is abundant on the outlying skerries and lower shores of Rona, and as we approached the island numbers of these animals were seen somewhat in the locality indicated in our sketch. We

fishermen give different numbers, and do not agree among themselves. John Morrison states the numbers as follows: in 1885, 89 on Rona; in 1884, 143 on Rona; in 1883, 107 in Rona; in 1882, 30 on Sulisgeir only."

"I have received," writes Mr J. N. Anderson, Danish Consul, Stornoway, *in lit.* July 24, 1886, "for the past few years most of the skins of the seals killed [on Rona or Sulisgeir], and their number has been from 120 to 150."

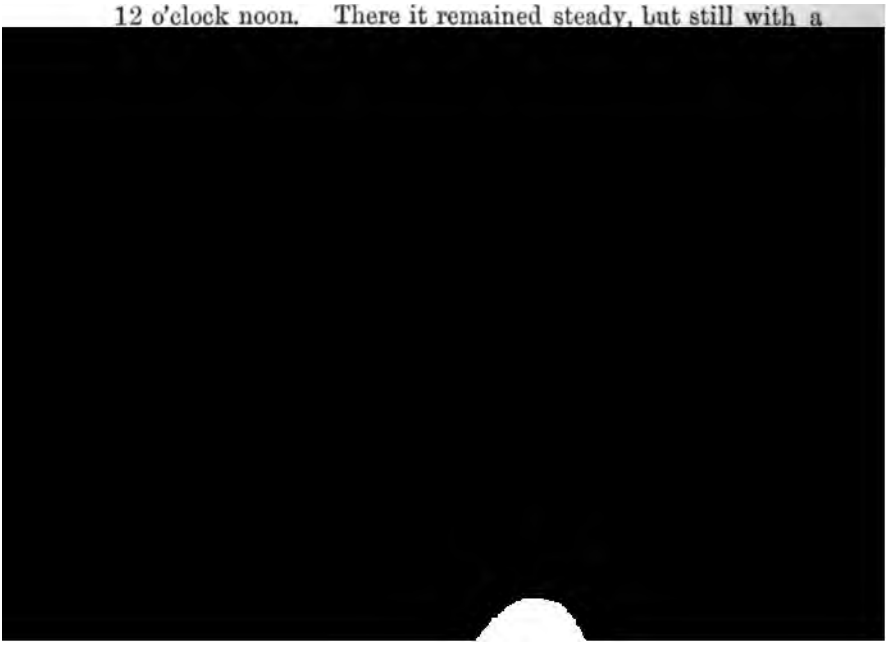
Regarding the botany of North Rona, Mr R. M. Barrington could say a great deal more, no doubt, but he has kindly sent the following list of species, which may interest many of our members. He prefixes his list with the remarks: "I was too early; but the flora is remarkable for its poverty: *Plantago maritima* absent, and *Ophioglossum vulgatum*, var. *ambiguum*, abundant. These are the two salient points. I noticed 35 species, to which a few might be added later on." The following is the list supplied by Mr Barrington. Having no botanical knowledge ourselves, much to our regret, we can only hope that some day Mr Barrington will add some account of this branch of natural history to the knowledge of these insular groups, many of which he has personally inspected. Meanwhile we always consider it desirable, in treating of these insular positions, to place on record what is already known.

PLANTS OBSERVED ON NORTH RONA, JULY 1, 1886.

Ranunculus Flammula, Linn.
,, *repens*, Linn.
Cochlearia officinalis, Linn.
,, ,, var. *alpina*.
Cerastium tetrandum, Curt.
,, *triviale*, Link.
Stellaria media, With.
Sagina maritima, Don.
,, *procumbens*, Linn.
Montia fontana, Linn.
Trifolium repens, Linn.
Potentilla Anserina, Linn.
Hydrocotyle vulgaris, Linn.
Ligusticum scoticum, Linn.
Angelica sylvestris, Linn.
Bellis perennis, Linn.
Matricaria inodora, Linn.
Leontodon autumnalis, Linn.
Armeria maritima, Willd.
Glaux ,, Linn.
Plantago major, Linn.
,, *coronopus*, Linn.
Atriplex Babingtonii, Woods.
Rumex Acetosa, Linn.
,, *Acetosella*, Linn.
Luzula (*campestris*, D. C. ?).
Eleocharis palustris, R. Br.
Eriophorum angustifolium, Roth.
Carex vulgaris, With.
Aira præcox, Linn.
Holcus lanatus, Linn.
Poa pratensis, Linn.
Festuca rubra, Linn.
Nardus stricta, Linn.
Ophioglossum vulgatum, var. *ambiguum*, Linn.

The difficulties of landing on Rona, we believe, are not exaggerated; indeed, it must be granted that the place is extremely difficult of access. Considerable colour is, no doubt, always given as to the difficulty of landing at most of these outlying islands; still there is reason to believe that for weeks together landing is quite impossible. Mr H. G. Barclay and myself tried to reach Rona this year no less than four times before we succeeded, and only once did we even come within sight of the island. Our yacht, hired through an agent on the Clyde, was somewhere about 95 feet in keel, and about 13½ to 14 feet in beam; in fact, a river boat. So bad was she, that we were either imprisoned at Stornoway, or at Loch Inver, or at Loch Laxford, having to run for shelter even in a very moderate sea. At last, on the morning of the 16th June, we steamed out of Loch Laxford about 10 A.M. Ground swell only—no long rollers—not a breath of wind—luck at last. Horizon clear, but slight heat haze over both land and sea, which I predicted would bring up a gentle land breeze—easterly—at night, which the sequel shows was correct.

Weather, *pro tem.*, apparently as distinctly settled as in twenty years I have ever seen it on the West Coast at this season; yet the glass—aneroid—went down one-tenth by 12 o'clock noon. There it remained steady, but still with a



spades in the house. These we found and used, but the crowbar would have been very useful, although heavy to carry up. The steward, one of the crew, and our pilot (Norman Macleod, who also was with Swinburne) accompanied us, and we drew the boat up high and dry on the rocks.

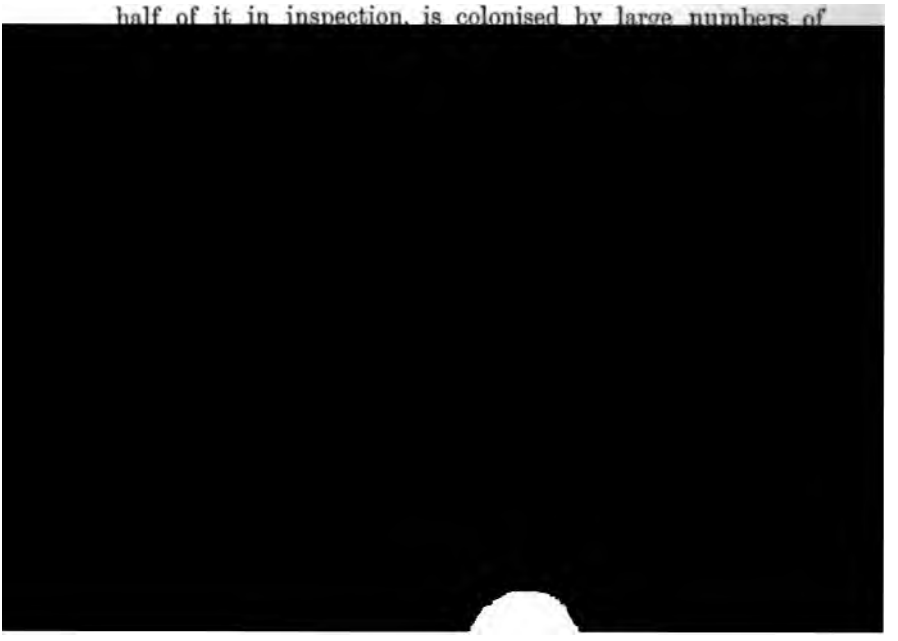
We made direct for the Fork-tailed petrels' breeding-place among the ruins of the old village, and worked nearly an hour and a half at excavating the Petrel's eggs, but were not quite so successful as Mr Swinburne, who obtained rather more specimens than we did. Amongst the Petrels were three Stormy petrels, which we caught in the holes, but they did not appear to have eggs. We kept these as specimens, along with seven examples of Fork-tailed petrels each caught on its own egg. The others we let away, and I tossed several up in the air in order to observe the flight. It was very curious in the broad daylight—strange, graceful, zig-zag, uncertain, wavering; part bat-like or butterfly-like, part swallow-like or pratincoline, part snipe-like, if I may be allowed to attach so many adjectives. They flew first in circles round their breeding haunt, and in a few seconds made away down the slopes towards the sea, the light-coloured pale smoky coverts showing to great advantage beside the other dark plumage, and the white tail-spot very handsome and distinct. I should have liked to toss up the Stormy petrels also, in order to compare the flight of the two species, but as I only obtained one, and did not feel sure that the species had been previously recorded from North Rona, I preferred keeping the specimen.

The single eggs of each bird lay at the extreme end of the tunnellings, deep amongst the stones and sea-pink-covered turf-walls of the long-since desolated village. Our men, as well as ourselves, worked heartily with the spades, but we took with our own hands all the eggs except four. In one hole only did we find two birds with the single egg.

The ruins are on the southern slope of the island, as shown on the sketch, and are of considerable extent, surrounded by a large number of old cultivated patches of land, showing the "lazy-bed" method of potato-cultivation, but now covered

over again with good grass and sea-pink mounds. There appears to be about 9 inches of good mould, and what in a good season would be quite a luxuriant growth of grasses. At a little distance from the houses the turf had been cut off the surface for fuel or for building purposes—a custom also adopted by natives of St Kilda. Here the surface wounds soon heal up, and become covered with grasses, but in St Kilda the contrary is the case, and often the denuded patches do not again bear any turf covering. From the whole southern slope, loose stones have been gathered off, and these now stand in cairns here and there, affording shelter and nesting ground for a few pairs of wheatears.

Leaving the high south hill of Rona, we descended the steeper slope on the north side, above the place where our boat had been pulled up on the rocks. The dirt and the heat, and the petrel oil which the birds freely administered to us, made us extremely glad to have a long pull at Silvers' water-bottle. Coming down the slope, I endeavoured to take a rough outline of the low north promontory of Rona, which I have preserved in my journals, but think it hardly worthy of reproduction here. But time was flying, and we were a long way off, in a crazy ship, with a falling barometer. The northern end, so far as we had time to get over about one-half of it in inspection, is colonised by large numbers of



nest or young; but I was not "captain of the watch," and the whistle sounded punctually at 6 o'clock P.M., the hour at which promise had been made to return on board. The weather was settled, a gentle easterly land-breeze was just commencing, and there was a scarcely perceptible haze to the westward. Besides the Whimbrels, I saw one pair of Ringed plover—another addition to the Rona list—also evidently breeding, and many Oystercatchers amongst the broken ground of the Puffin slopes.

Having left the island, we steered for Stornoway. We stayed late on deck, and turned in reluctantly at 1 A.M.; we awoke at 7 A.M. next morning in the harbour of Stornoway, with half a gale of wind shrieking outside, and mingling its uproar with the unearthly moans and caterwaulings of the tug-steamers and other small steam-craft. Why the latter do this hideous thing concerned us not, except in so far that we would fain have rested more tranquilly than was permitted to us to do.

Taking Mr Swinburne's list as a basis, and adding thereto our own observations and those of Mr Richard M. Barrington, who visited Rona in 1886, and stayed three days on the island, viz., between June 29th and July 1st, inclusive, we now place the avi-fauna on the following footing:

Saxicola œnanthe—the Wheatear, included by Swinburne. —Seen not uncommonly by us in 1885, flitting about amongst the cairns of gathered stones—perhaps three or four pairs, perhaps less. One bird seen by Barrington, who thinks it was breeding.

Motacilla lugubris (Temm.)—Pied Wagtail.—One specimen was seen near the stone hut catching blue-bottle flies on dead Shags (*fide* W. Williams).[1]

Motacilla raii, Bonap.—Yellow Wagtail.—One female shot.

Anthus obscurus (Lath.)—Rock Pipit.—Observed by Swinburne, and commonly by ourselves and R. M. Barrington, who obtained a nest.

Anthus pratensis, Linn.—Noted by Swinburne; not seen by us, nor included by Barrington.

Passer montanus (Linn.).—Not seen by Swinburne nor by

[1] One of Mr Barrington's party.

us, but five seen together by Barrington, and three shot—two males and a female. Barrington thinks they were breeding.

Hirundo rustica (Linn.).—A pair seen on the north side about the cliff (*fide* W. Williams), 1886.

Chelidon urbica (Linn.).—One shot 1886.

Strepsilas interpres (Linn.).—Five seen on rocks between high and low water-mark by Barrington's party. Summer plumage not complete. According to our experiences of the Outer Hebrides and West of Scotland, this is usually the case in regard to the plumage of Turnstone when seen in summer there; but we have seen birds in pairs, on several occasions also, in full summer plumage, or almost perfect breeding dress. We have seen many Turnstones and many Purple sandpipers in June on many parts of the Hebrides and West Coast, but we cannot on any one occasion recollect an instance in which the actions of these birds would lead one to suppose they were breeding, except once, when Purple sandpipers were found high up on a hillside, and others—females—were shot on the shore line, with ovaries not very far advanced in development, but the birds in very nearly perfect breeding dress. This was during the last days of May. We think it quite possible Turnstones may have bred, or if not, that they may yet extend their breeding range in

of these birds on the northern peninsula of Rona, and, as already related, all their actions were distinctly indicative of their having a nest or young. This seems an interesting link in the breeding distribution of the species—*i.e.*, if we accept our own experience of bird-action as indicative of breeding; and as we know that Rona lies in the direct main line of their spring migration, such an event happening is scarcely to be wondered at, if we regard also their presently known breeding range. The nearest point at which the Whimbrel is known to breed with certainty, to my knowledge, is on one of the southern islands of Orkney, and this they did certainly twenty years ago. Faroe and Iceland seem to be their headquarters in the west of Europe. They pass most numerously north along the coasts of the Outer Hebrides in May, more abundantly on the west coast than on the east coast, occur not so abundantly on the Inner Hebrides, comparatively scarcer on the west coast of the mainland, and still more infrequently on the East Coast of Scotland. They are known, however, by us to cross over Scotland at certain passes, as, for instance, up the Spean Valley, and down the Spey in spring. The distribution and migration are in great measure dependent upon one another—a simple fact which must force its importance upon the notice of ornithologists as regards many species.

Barrington shot one male bird on Rona in 1886, but it does not appear to have been noted by Swinburne. The birds we saw were *silent*, crouching, and running, and did not get on wing. All their actions were distinctly those of breeding birds. The birds that Barrington saw, he thinks, were not breeding.

Charadrius hiaticula (Linn.)—Ringed Plover.—We met with one pair of the Ringed plover on the north peninsula, evidently nesting, though neither Swinburne nor Barrington seems to have seen the species on the island.

Falco peregrinus, Linn.—Peregrine Falcon.—Swinburne observed a pair near the south-west part of the island, where he considered they had a nest, "from the outcry they made when that portion of the island was approached." We saw nothing of them in 1885, but we did not go near the cliffs of

the south-west side owing to want of time. Barrington does not appear to have observed them in 1886.

Sterna macrura (Naum.) — Arctic Tern.—Not noted by Swinburne. Observed by ourselves on the northern peninsula; and Barrington found nests and a colony of about thirty pairs, one bird from which was "shot to make sure."

Larus argentatus, Linn.—Herring Gull.—Swinburne saw several pairs; we found a few; and Barrington found "several breeding, but not so common as the next species."

Larus fuscus, Linn.—Lesser Black-Backed Gull.—Swinburne "did not notice any Lesser black-backed gulls," though he had "no doubt they were there," but neither did we meet with the species on the island. Barrington marks them as "plentiful, breeding at the south side," and also includes the next species; so there is no doubt that all three of our common large gulls inhabit the island.

Larus marinus, Linn.—Great Black-Backed Gull.—Swinburne mentions the large colony "breeding on the low point at the west end of Rona." We found them "apparently in a colony, but did not reach the nesting locality;" and Barrington says, "Plentiful, breeding in larger numbers than I have seen it anywhere on the British coasts."

Rissa tridactyla (Linn.)—Kittiwake.—Large numbers on north side of Sulisgeir, and also on the north-west side of

have already given (*supra*). It appeared difficult to estimate their numbers, but we are surely below the mark if we put them down at from 60 to 80 or even 100 pairs at the old houses, and it is possible more may be found on other parts of the island.

Procellaria pelagica (Linn.)—Storm Petrel.—While Swinburne did not meet with any of this species, and we only obtained two sheltering among the corridors of the Fork-tailed petrels' colony, Barrington found a large colony on the western end, where there were none of *P. leucorrhoa*, and also found one or two *P. pelagica* in the colony of *P. leucorrhoa* on the south-east side. "The churr of the stormies at nights," adds Mr Barrington, "was very loud, hundreds churring under stones at the same time."

Alca torda, Linn.—Razorbill.—Found plentifully by all of us, and on Sulisgeir by Swinburne. We found "a very fair colony of the two species (Guillemot and Razorbill)," the Razorbill the more abundant of the two.

Lomvia troile (Linn.) — Common Guillemot.—Common. The ringed variety was found by Swinburne, and eggs taken from below the birds; Barrington estimates their numbers at 17 of the latter to 64 of the former counted. We did not have time to look into this matter.

Uria troile (Linn.)—Black Guillemot.—Swinburne found a good many about the west end of Rona, and Barrington found them breeding in the walls of the old dwellings a hundred yards from the sea. "During the day," says Mr Barrington, "they sat sunning themselves on the grassy roofs of old houses. Never found this species breeding before except in clefts of rocks and cliffs not high from high-water mark." We saw nothing of this species in 1885.

Fratercula arctica (Linn.)—Puffin.—Breeds abundantly. Most numerous at the west end, according to Barrington, but we also found great numbers on the north peninsula. Swinburne speaks of it as "swarming."

Phalacrocorax graculus (Linn.)—Shag.—Abundant. None of the larger species noted by any of the parties.

Sula bassana (Linn.)—Gannet.—Breeds on Sulisgeir, and Swinburne speaks of "2000 to 2500, and in some years as

many as 3000 young birds" being taken, "being more than double the number which are got from the Bass Rock in the Firth of Forth, where in some years not more than 800 are obtained." We only observed the Gannet at sea, as also did Barrington.

Somateria mollissima (Linn.)—Eider Duck.—Very abundant as observed by all the parties. Barrington has the note, "very few male birds observed." This species has spread and increased marvellously throughout the Outer Hebrides within our recollection, and we hope at another opportunity to trace its steps of advance more minutely, dating back for a considerable number of years.

Records of Rarities Exhibited or Reported to the Royal Physical Society of Edinburgh in 1885.

(Continued from Vol. VIII., pp. 498, 499.)

No. of Record Form.	Date.	Locality and District.	Species.	Age—Ad. or Juv.	Sex.	Alone or in Company.	With its own, or other Species.	Comparative Nos.	Flying in which Direction when seen or shot.	If caught or killed at Light, on which side—N., N.E., N.W., S., S.E., or S.W.	Direction of the Wind at the time, Strength, and Weather.	Prevailing Winds for past 9 days. past . . . weeks.
	1885. Sept. 9.	N. Unst, Shetland.	Wryneck, *Iynx*	bird.	♂	ught.	Rush of birds		S.E. ight.	West. force,	Bar. W. and N	erly.

NOTES AND REMARKS.

No. 12.

If along with other species, mention the names of the latter here;—Stormy Petrels, Siskins, Redstarts, Wheatears, and Pipits ("Moss-cheepers").

Destination of Specimen.—Wings and tail sent for identification.—J. A. H.-B.

Recorded in this Volume (IX., p. 298) of *Proc. Roy. Phys. Soc.*, 1885-86.

Footnote.—Remarks may consist of further Field, Dissection, or Cabinet Notes of Recorder.

No. 13.

Larks, a few. Reported and sent by Mr James Youngclause, Sumburgh Head lighthouse, formerly lighthouse-keeper at Monach Island, *where*, by his account (*in lit.*), an "identically similar bird" appeared on one occasion previously. [See his letter of 25th September 1886.]

At present at Dunipace House. Intended for the *Industrial Museum*, Edinburgh. (Preserved in alcohol.)

Recorded in this Volume (IX., p. 298) of *Proc. Roy. Phys. Soc.*, Edinburgh.

Identified by J. A. H.-B. Confirmed by Professor A. Newton, Cambridge. Exhibited, *Royal Physical Society*, Edinburgh, 17th November 1886.

No. 14.

Was shot resting on a corn stack "Never seen here before" (JOHN GILMOUR, Assistant Keeper).

At Dunipace House at present.

Recorded in this Volume (IX., p. 298) of *Proc. Roy. Phys. Soc.*, Edinburgh.

Skin and feet sent.

Another is reported as seen by the lighthouse-keeper at North Unst, and identified by him from Johns' "British Birds in their Haunts," copies of which have been distributed by the Migration Committee.

PROCEEDINGS

OF THE

ROYAL PHYSICAL SOCIETY.

SESSION CXVI.

Wednesday, 17th November 1886.—JOHN A. HARVIE-BROWN, Esq., F.R.S.E., F.Z.S., Vice-President, in the Chair. [Plates XII., XIII.]

The CHAIRMAN delivered the following opening address:

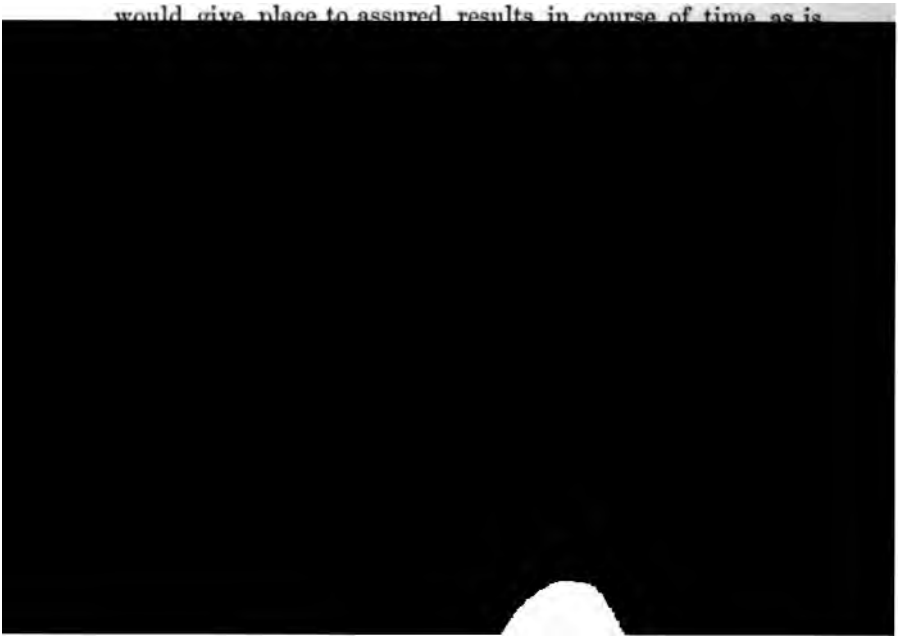
GENTLEMEN,—Before reading to you the paper which I present you with as my address, I would shortly refer to the loss this Society has sustained in one of its brightest ornaments, —the late Mr Charles W. Peach,—whose great ability as a naturalist, whose genial character as a man, and whose obliging disposition at all times, has won for him an enduring admiration. It is not my intention in this place to review a life which already is, or ought to be, known to every Scottish Naturalist. It has been told, and felicitously told, by Mr Smiles in his "Life of Robert Dick;" and in that most interesting volume is also given an equally happy portrait of him whom we now deplore.

I would also refer shortly to the continued prosperity of our Society, and the wealth of scientific matter contained in the *Proceedings;* to an increase of working members, and a greater general interest in the work, as new fields and new branches of discovery are opened up, and as more and more members are enrolled.

If, in a Presidential address, I may be allowed to suggest a future field of work, which has not hitherto, perhaps, re-

ceived as much share of attention as it deserves, I would recommend the more minute and accurate recording of the *Distribution of Fishes* around our coasts, and in our lakes and streams; and would desire to see carefully prepared lists of species from each drainage system, and their final catchment basins, in Scotland. Such lists, in time, could not fail to be of great interest and value, scientific and economical, and greatly to assist us in the future, in arriving at conclusions regarding distribution and migration, as well as the life-history of this important class of our Vertebrates. The distribution of fish at certain seasons of the year is the only firm basis on which to build up the truths of their migrations from one place to another. Once these facts are ascertained, other interesting discoveries are sure to follow. Even artificial fish-culture can hardly be said to be perfected, or to reach further than its own circumscribed limits, at least in an economical sense, unless these correlating and important facts be also gathered.

Fish-culture, as fish-culture alone, is still to a great degree experimental. But if it were better supported by accumulations of data and facts as regards distribution (say of other inimical species), and as regards the migrations and food-supply of each and all species, everything experimental would give place to assured results in course of time, as is



ance of the Isle of May purely from an ornithological point of view, under the title—

"THE ISLE OF MAY:[1]
Its Faunal Position and Bird Life."

1*st*, In the following paper it is my desire to describe the Isle of May purely in its relationship to its faunal position, and as regards its importance as a halting-place or beacon-light in the path of the bi-annual routes of migration of birds to and from the continent of Europe in spring and autumn; a position which it holds in common with many other localities to the southwards along the E. English coasts, but with very few, indeed only two, other stations, viz., Bell Rock to the northward on the Fife coast, and Pentland Skerries in the Pentland Firth, between the Orkney Islands and the Caithness coast; although a third very important path is not guarded by a beacon—viz., the line of the great Moray Firth Migration. In order to do this, it is necessary to allude to the relative positions of certain lands at present separated from the Isle of May by ocean, but formerly joined to it by land, which latter, though now submerged, was continuous with Europe, and reached out into the North Sea to what is now known as *The hundred-fathom* line. I do not enter upon this description with the intention of theorising regarding migration on the same standard as Herr Weissman did in his well-known paper in the *Contemporary Review*, although I am far from scoffing at the theory he promulgated; but I do so in order to define both the past and the present faunal position and importance of the Isle of May, and simply to state broad facts known to our scientists.

2*d*, It is also necessary, for a clearer perception of the present faunal value of this position, to give, as shortly as possible, some at least of the now un-

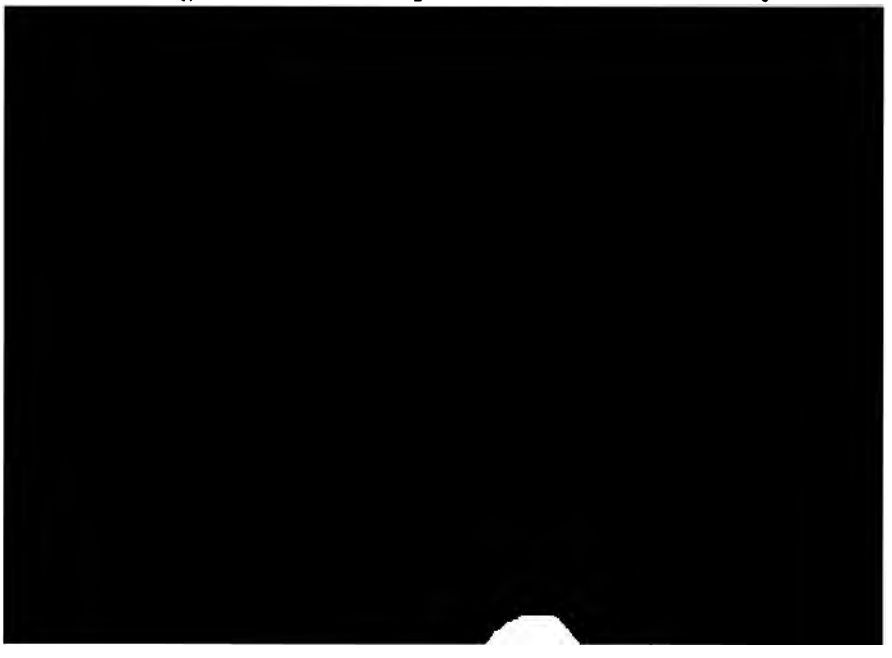
[1] From the Gaelic *Eilean Maith*,—the English interpretation meaning the Good Isle.—A. CARMICHAEL.

doubted facts regarding the migrations of birds which, during the past few years, have been brought to light and established by statistics collected for the Migration Committee of the British Association.

3d, I will also describe the present aspect, surface, and general physical geography of the Isle of May as it has been ascertained by personal inspection on more than one occasion, one of which, during part of the autumn migration of 1884—viz., in September and October—extended over three weeks and three days, and other visits which were taken advantage of during the breeding season of the summer visitants.

4th, I will treat of the actual bird-life of the island, carefully re-editing what was previously known of its bird-life, and condensing the records of its passing migrants during these years in which the aforesaid Migration Committee has been at work; and I will read the introductory portion of this fourth division of my paper, and notes upon the species which are found breeding on the island.[1]

Lastly, We consider that the time at which we desire to give the aforesaid particulars of the Isle of May is



of the Committee. Meanwhile, we consider it a privilege to be the recorder of a considerable portion of the results—brought up to the date of the present time—of the able and careful work of Mr Agnew. The Eighth Report of our Committee will contain the last year of Mr Agnew's observations at the Isle of May.

Taking, then, these several headings in their consecutive order, I will first speak of the island of Heligoland and the continent of Europe in their relationship to Great Britain and the Isle of May and to migrational phenomena.

1. Heligoland is a steep, bold, red sandstone rock, with level surface and precipitous sides, and is clothed over the larger portion of its summit by stretches of potato-lands belonging to the inhabitants. It rises from a great expanse of shallow sea and sandbank opposite the mouth of the River Elbe, and is some 46 miles N.W. of the mouths of the Elbe and the Weset Rivers. It is in Lat. 54° 11′ N., and Long. 8° 14′ E. (Compare, for purposes to be explained further on, its positions in latitude and longitude with those of the Isle of May.)

Undoubtedly, at a remote period—yet a comparatively recent one in geological time—Heligoland was united with the adjacent continent of Europe, and also with the further-off Isles of Great Britain, and with the now submerged Dogger Fishing Banks in the German Sea, which are at the present time about 9 to 15 fathoms beneath the surface of the ocean. The Hundred-Fathom line encircling Great Britain, or rather forming it into a great N.W. peninsula of ancient Europe, clearly shows this. This great N.W. peninsula, which included Great Britain and Ireland, and the lesser isles of Shetland, Orkney, and the Hebrides, extended, at its apex, to a position in degrees of latitude opposite to the coast of Norway, in about Lat. 61° N., or the latitude of Bergen, and was joined to the continent at the northern extremity of Jutland; and reached down and outside the British Isles to a considerable distance S.W. of the Land's-End in Cornwall, and approached again the French coast at Cape Finisterre, and finally continued along the W. coast of France

to Spain, where, however, the sea rapidly deepens close off shore.

A reference to the Admiralty charts of the North Sea and British seas will satisfy, I believe, inquirers in the above directions; *or*, if a study of these entails too much labour, a glance at a map, reduced from the same, "of the N.W. portion of the European Continent during the earlier part of the Glacial Period, showing the land area produced by an uprise of 600 feet above the present sea-level, Snowdon being then 5200 feet high" (which map is contained—as also are the above words I quote—in Professor Rupert Jones' "Lecture on the Antiquity of Man," Van Voorst, 1887), will suffice to further explain what I have said. To this part, I have only to add, that a glance at the same map will show that, between the extended line of the 100 fathoms' depth and the coast of Scandinavia a deep trough occurred, which separated the peninsula of ancient Europe from Scandinavia, and into which all eastward- and northward-flowing rivers from the peninsula debouched. The soundings of the Admiralty sufficiently localise the positions of these ancient river-beds, even in later years.

Passing from Heligoland and the Continent now to the Isle of May, I desire to emphasize its relation to the former.

nection with our previous remarks, undoubtedly assist us in fixing the faunal value of the position of the Isle of May, and indicate, in a very considerable measure, its importance.

It has been ascertained, with regard to the migrations of land-birds across the North Sea and concerning the areas which they cover in certain winds—whether these winds aid or impede their flight—that certain fixed laws exist beyond reasonable doubt of contradiction. It is not my intention to speak of all these laws in detail, but only to show, so far as I can, the distinct and direct bearing of *some* of these laws upon the migratory fauna of the Isle of May.

The first axiom I may state is: (*a.*) The line of the autumn migration of land-birds across the North Sea invariably takes place from easterly directions to westerly ones, or from directions south of east to north of west. This great autumn movement is influenced from year to year by the prevailing winds, which may, in some measure, retard or hasten on the movement, according to its strength, exact extent of area, direction, and duration. At Heligoland, however, influence of the wind seems to be less exerted, as migrants cross from E. to W., or thereby, over that island with marvellous regularity of dates and direction.

Another axiom is: (*b.*) Birds prefer to travel with a *beam* wind, that is, with a wind from two to four points, according to strength of wind, against their line of flight; because this wind smoothes down their plumage and keeps it close to the body, and enables them to use their tails as rudders. *But* birds do *not* willingly migrate with a following wind, or start upon a journey with a following wind, as such destroys their equilibrium and ruffles up their plumage, and renders it vastly more difficult for them to steer their course. But yet it often happens that, caught unawares in the most unfavourable winds and weather, many thousands of land-birds are carried helplessly away miles out of their intended course, and drowned hundreds, even thousands, of miles out in the Atlantic.

A third axiom is: (*c.*) Should N.W. winds prevail in autumn upon our east coasts, or westerly winds, or even south-westerly winds, normal migration ensues. Such are

the normal conditions of our Western Isles and their meteorology. But should easterly winds prevail in autumn, or south-easterly, abnormal results are sure to follow, east winds being abnormal at that season.

The wave of bird-migration in our reports has been likened to a *fan*. The normal lines of flight we have seen are E. to W., or south of E. to north of W.; but if the wind be northerly, or north of W., the effect is to press down to a great extent the rays of the fan, or cause what, in our reports, has been termed a *close fan* of migration. Accordingly to the extent of strength and *northering* of westerly winds will the *closeness of the fan* be.

If, on the other hand, easterly winds prevail, following, overtaking the migrants, according to the extent of its *southering* and *strength* will the *opening out* of the wave or *fan of migration* be, causing what we call an *open fan* of migration. If a succession of easterly gales takes place, thousands of migrants are carried away over the Atlantic and drowned in the ocean; but if a succession of N.W. gales occur at the same season, the flights of migrants are beaten down, compressed, and obliged to fly low over their routes. If, again, light westerly winds prevail, migrants travel easiest, reach furthest, feel least exhausted, and normally extend

recognised through a powerful telescope at an elevation of *four miles!* passing the disc of the moon, on a clear star-lit night; and even the species was recognised,—if I remember aright, the Curlew (*Numenius arquata*).

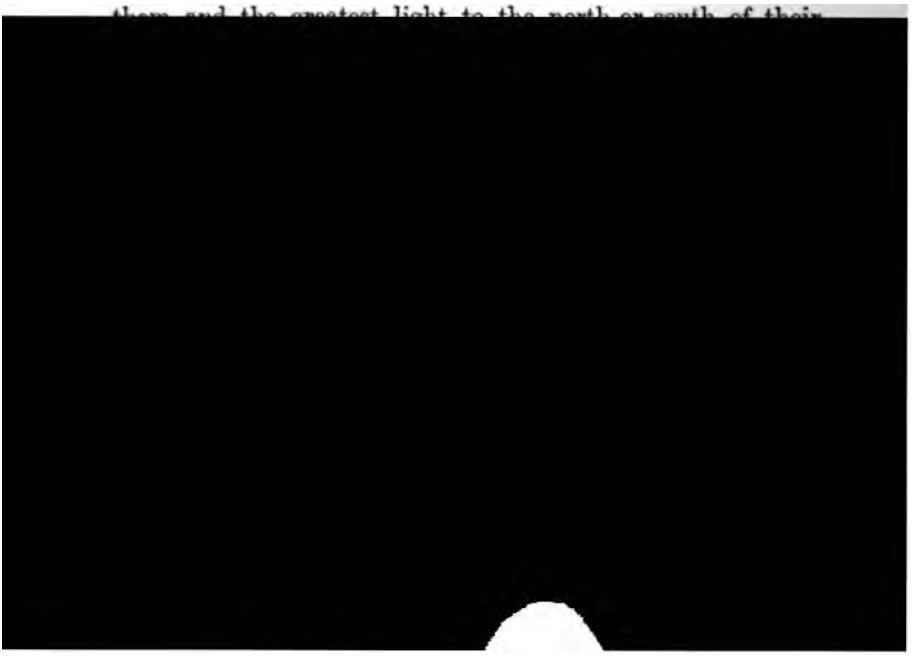
(*e.*) Birds in passage over Heligoland have often been observed by the veteran ornithologist of that island—Herr Gaetke (than whom, I presume, no man in Europe knows more of his subject)—to pass for hours and hours of daylight, in uninterrupted flights, high overhead, from E. to W. Then, with one of these sudden changes of temperature peculiar, possibly (?), to the North Sea and British coasts, a dense fog, a Scotch mist, a Danish "haar," quickly covers sea and land as night sets in. Almost simultaneously with it come myriads and legions of migrants, lured by the intense white rays of the lighthouse. Herr Gaetke says: "A rapid descent from the higher altitudes, at which previously they were travelling, takes place, because, mist or fog beneath blotting out their bird's-eye landmarks, yet indicate resting-places and LAND in the midst of ocean." What does this prove? That in clear, bright weather—even at vast altitudes—the birds' vision maps out beneath them vast tracts of land and ocean, by which visual guidance they proceed; but that when haze and mist obscure and blot out the land and sea beneath them, a sudden descent takes place in search of these blotted-out landmarks; and the vivid rays of lighthouses and lightships lure them in multitudes, to rest, or to destruction! Even our modern balloonist knows that earth—viewed from heaven, as it were—is a vast bird's-eye view. If a mariner, from his crow's-nest on his mast-head, can see twelve to fifteen miles of distance between his ship and the horizon, tell me how many more miles will a bird see at an elevation of four miles' altitude? To what extent the power of vision of many birds amounts to must remain still undefined; but it may yet be discovered to be so intense as greatly to relieve students of migration of one of their chief and most intricate and difficult subjects, by accounting, in part at least, for one of the more obscure phenomena.

One other point we will mention here, which we consider

is brought out by our Reports, and that is as follows; and which we believe may be stated as an axiom.

(*e.*) Whilst all along the eastern seaboard of England, which for the greater part of its extent is low-lying, vast flights of Larks, and many other species of migrants, flow on over the land in uninterrupted waves; on our Scottish east coast the waves of the migration are more compressed, and flow in narrowed company up the depressions, which are more marked in a mountainous country, or on a rock-bound shore. It is thus that points of special vantage for an observer are supplied by such stations as the Isle of May and Bell Rock at the entrance of the Firth of Forth, and Pentland Skerries at the eastern end of the Pentland Firth. We have, in our last Report (copy of which I lay on the table), pp. 6-9, spoken at some length regarding the action of flights of birds on approaching high sea-cliffs, such as those of St Abb's Head, and the greater part of our Scottish coast; and perhaps I may be allowed shortly to quote a passage which will explain our views on this subject:

"Birds in normal migration against a beam wind fly low, and on reaching low-lying seaboard pass on inland without resting. But on approaching high land, say 200 or 300 feet in height, while at night the greatest darkness is ahead of



above sea-level. But the primary reason why they do not come within the influence is because they do not, in normal migration, rise high enough to come opposite these central rays.

The above remarks apply equally at the several principal points where great concentration of the migrants takes place. Applying them more directly to the Firth of Forth we would state it thus: "While comparatively few birds fly across the cliff-edges of Berwickshire, but pour in vast streams up the open Firth, at the same time, in easterly winds, especially if high, birds are often borne numerously over the tops. In normal westerly winds, however, migrants which pour up this great channel throw off their thousands out of their tens of thousands wherever the lower-lying shores are arrived at inside of the Firth, and the 'return' in Spring is equally apparent." Thus the interior of Scotland, south of the Firth of Forth, is mainly populated by migrants in Autumn *via* the Firth of Forth; detachments, however, entering the country at Berwick, and probably smaller detachments at the mouth of the Haddingtonshire Tyne. Hence is it that we find the south shore of the Firth of Forth populated by autumnal flocks of waders, and by the return, but smaller, flocks in Spring. We look upon the Isle of May as the northern extension, along with, probably, Bell Rock and the Tay, and a portion of the Forfarshire coast, of the waves which cross from the direction of Heligoland. We do not look upon these statements as theoretical now, but as almost proven in their general accuracy; any occurrences to the contrary being the exceptions which prove the rule.

Beyond the above remarks I do not purpose venturing very far here, though there are more abstruse questions which are forced upon the students of migration. We will merely indicate these. There are curious facts concerning the early advent on our shores of the young of the year, of many species, as compared with the later advent of the adults, which are still veiled in comparative obscurity. There are questions of *Extension of range* of species dependent upon abnormal seasons of migration, which are still somewhat intricate and uncertain, but concerning which, the correct

arrangement of very considerable data are, to our mind, already within actual grasp. In concluding this part of my address, I will only further quote a few sentences of Dr Andrew Wilson, Dr Carpenter, and Sir John Lubbock, and endeavour to place upon some sort of footing the present state of knowledge—or of hypothesis—regarding the former of these phenomena, which may, and doubtless will, act as a clue to others who are specially interested in the subject:—

Dr Andrew Wilson said: "We know too little respecting the so-called 'automatic' powers and ways, even of higher animals, to dogmatise regarding the acts of lower animals; but we may safely assume that one apparent ground of distinction between instinct and reason may be found in the common incompetence of instinct to move out of the beaten track of existence, and in the adaptation of reason, through the teachings of experience, to new and unwonted circumstances."

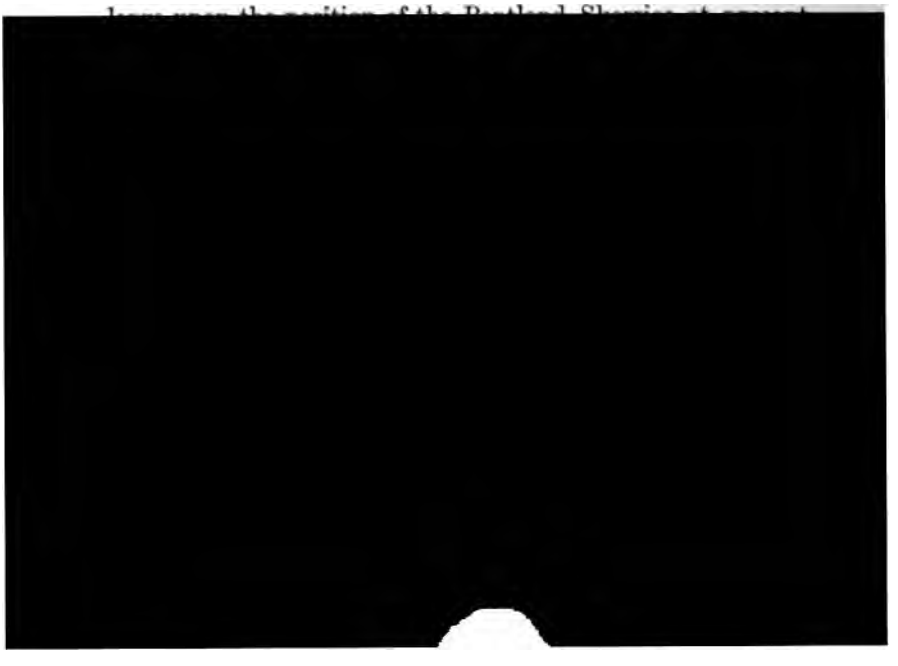
. . . "The highest instinctive powers," says Dr Carpenter, "when carefully examined, are found to consist entirely in movements of the *excito-motor* and *sensori-motor* kinds (*i.e.*, by impressions made on nervous centres, but without any necessary emotion, reason, or consciousness)."

Again, says Dr A. Wilson, quoting Sir John Lubbock: "The young ant, wasp, or bee will begin its labours, and

out the world beneath them; fog makes them descend to lower altitudes, as do certain currents of air; fog too often separates single weary travellers from the main bodies of migrants; and thus the only "tuition," or "example," is often removed from them; and no "consciousness," or "reason," steps in to fill the breach, at least in the case of young birds In the case of old birds, that have travelled the old groove once, or many times before, should they, in dark and misty nights, be separated from the flocks, "experience" steps in to set them right again. Hence it is that we find wanderers, and rare Eastern species, which occasionally are found upon our insular area, are for the most part young birds, more apt to stray from weaker powers of flight, and less apt soon to recover their lost tracks. In the case of adults, of rare and exceptional occurrence, we are inclined to believe that such are frequently found to be of species whose habitat is far far removed from the locality of their occurrence; and that whirled up in some cyclone, or terrible and resistless gale, and borne onward in blinding mist upon an erratic course, are finally dashed down, or forced to shelter, where they have never been forced to shelter (individually) before, perhaps thousands of miles north or west of their breeding or migratory range. It would be interesting to know *how could such birds as these return, if they do return at all.* If the gale occurred in clear bright weather, the great power of sight, and distinct retention of impression upon the nervous centres (we will not call it "reasoning memory"), would probably unerringly guide them back again. But if the gale occurred in mist and darkness, which sense would then invariably direct their return flight—the warmth of the sun, temperature, or what? or would great circular journeys be undertaken high in air, until some well *impressed* object meets the eye, and then, like the arrow-flight of the Carrier pigeon, lead it from stepping-stone to stepping-stone on this marvellous return journey, which, however, very many indeed never accomplish? I could extend this portion of the paper, but refrain, lest in the haze and still mystified courses of our subject I lose sight of our "Island of The May."

To sum up,—We can now see that the Isle of May is in

the direct track of migrants, and a very short distance north of the parallel of latitude of Heligoland. The distance to the westward being considerable, it is the more easily understood why certain species which cross over Heligoland do not, or only very rarely do, reach either the Isle of May or the east English coasts, but make their turning-point somewhere about Heligoland, and probably follow the old submerged, and the presently elevated valley of the Rhine, of which formerly all the rivers of England, south of Spurn Point and the Dogger Bank, were tributaries before the submergence took place, as well as all the rivers of Belgium, Holland, and Prussia flowing northwards. The Isle of May appears to me to be the northern limit (along with the Bell Rock and part of the Forfar coast) of the influence of migratory waves which cross Heligoland. *Because* in northerly and westerly winds migration at Isle of May is represented by a "closed fan," and by throbs and rushes; whereas, south of Spurn Point, the whole English coast is visited equally, whether the wind is a little northerly or not. Of course, much heavier returns occur with S.E. winds at all east coast stations. The migratory waves observed at Pentland Skerries we consider are *not* closely connected with the waves of those observed at Heligoland and Isle of May, but I shall not en-



stands the old beacon tower, now adapted for the conveniences of day-and-night-shelter for the pilots who make use of the central position of the Isle of May to watch the approach of inward-bound trading vessels, and which is now more generally known as The Pilot House. It is a rectilinear whitewashed block of masonry, some thirty feet square, or thereby, with a flat roof, upon which, in former times, the beacon-fires were kept constantly burning.

By following a narrow, trimly-kept, pathway towards the N.E., and descending to a level of about 55 feet above the sea, one reaches the low lighthouse, which serves, in combination with the higher lantern, to warn mariners of the position of the dangerous Carr Rock, which lies off Fife Ness, and is barely uncovered at low tide, extending, as I am informed by Mr J. Rattray, to about 72 feet in length by 23 feet in breadth.[1]

Below the lighthouse, to the S.W., is a cove or indentation in the otherwise almost uninterrupted cliff, known as the Mill Door, and above the Mill Door, and at an elevation of about 50 feet, is a partly artificial lake or dam of brackish and intensely green water, 6 or 8 chains in length, charged with innumerable confervæ. It is abundantly inhabited by eels, in the same way that I have found other lakes in similar positions on islands of the west coast. I failed to discover if it contains any three-spined Stickle-backs, or other fish. This lake lies between precipitous banks, nearly 100 feet in height; *that* on the west side broken, and clothed in luxuriant patches of sea-pink and other insular vegetation; but that on the east side much barer and stonier. This is a favourite valley for bird-migrants, owing to its sheltered position in easterly winds.

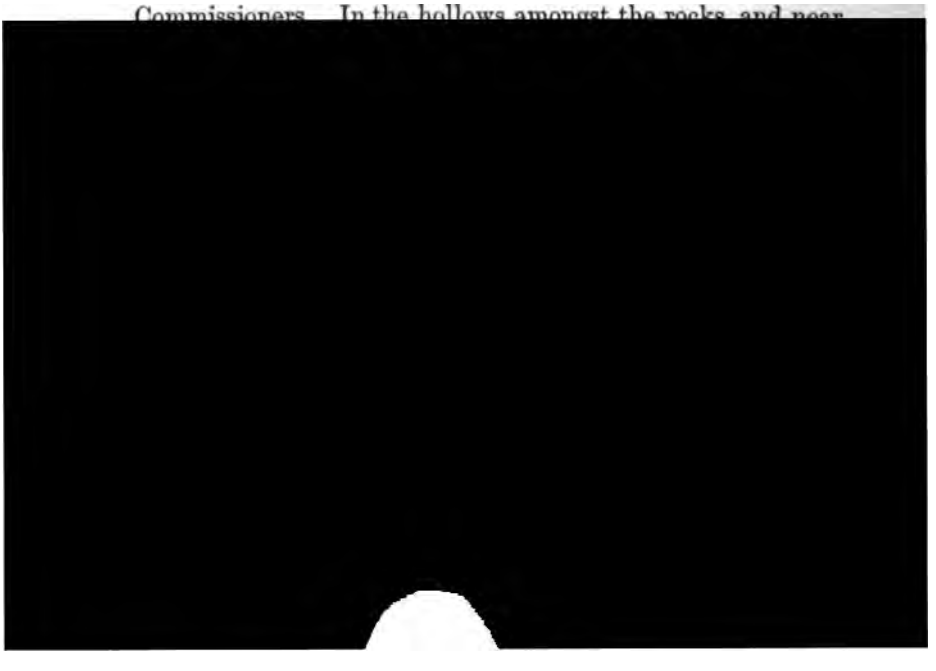
Close to the lake, and a few feet higher, in fact placed upon the watershed between E. and W., stand the farm-buildings, byres, barn, and other works connected with the lighthouse service, where motive-power and machinery has, since this was written, been established for lighting up the lantern by electricity. It remains to be seen what effect this change will have upon the migration of birds.

[1] Low Lighthouse was built in 1814, "Key of Firth of Forth," p. 23.

To the south of the farm buildings, and sloping gradually southwards, is a continuous chain of cultivated fields occupying a narrow hollow. These, along with two gardens, enclosed by high stone walls to protect the produce from the salt sea-brine, which sometimes sweeps over the whole breadth of the island, are worked and cropped by the men upon the lighthouse staff.

About the centre of this belt of fields, which is also surrounded on all sides with solid stone walls, are the ruins of the old Chapel and Priory of the Isle of May,[1] amongst the broken walls and crevices of which the Blackbird and the Thrush breed annually. Outside the extreme south wall, and close above the sea, is the Ladies' Cave and Well, and other caverns on the S.W. side, formerly the reputed haunt of water kelpies and smugglers (*see* "Key of Firth of Forth," pp. 27, 29).

Besides affording a certain amount of garden and agricultural land,—which, however, as I have said, is carefully protected by high stone walls,—the Isle of May affords abundant and sweet pasturage for some sixty sheep—when fully stocked—and six cows, the property of the three lighthouse-keepers who form the staff, besides a Clydesdale horse and three very purely bred donkeys, the property of the Commissioners. In the hollows amongst the rocks, and near



Altarstones," the latter at the Kirkhaven near the old Chapel and Priory. Close to the latter is a well containing the only potable water on the island, though it is slightly saline. Rain-water is caught in tanks off the lighthouse buildings, but the drinking and full supply of water is brought over from Crail on the Fife coast in breakers, and stored in other tanks.

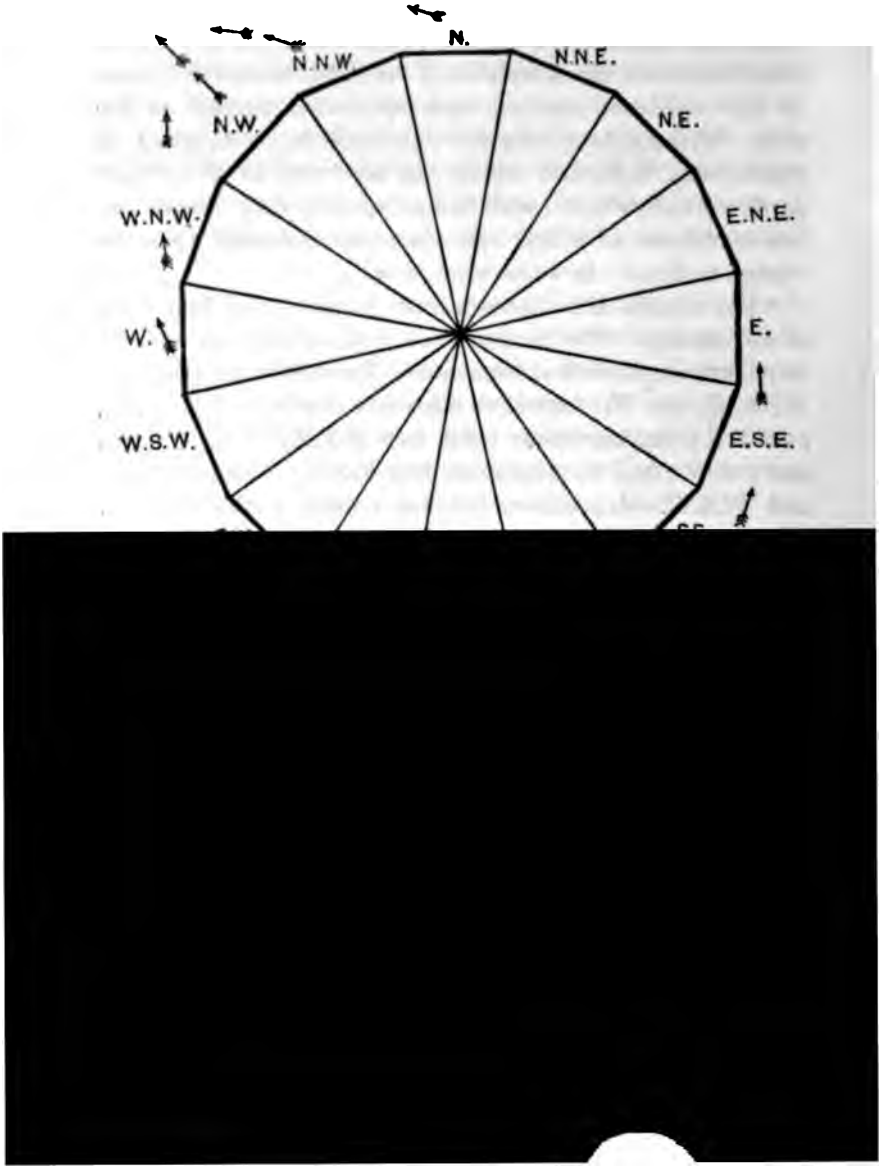
In connection with the position of the Isle of May and its faunal representation, I will now, in as few words as possible describe certain characteristics of the lighthouse, which come to be considered, copying from my journal written on the spot. Without describing the lighthouse in detail, which is unnecessary here, and which can be found in the fullest particulars elsewhere, I wish to note the following observation, the usefulness of which was often demonstrated when we wished to know "how the wind blew":

"The outside of the lantern-room is surrounded by a solid stone balcony. The lantern-room, both in external and internal arrangement, is sixteen-sided. Thus: four sides face due N., S., E., and W.; four more sides face due N.E., S.E., N.W., and N.E.; yet four other sides face N.N.E., S.S.E., N.N.W., and S.S.W.; and the remaining four E.N.E., E.S.E., W.N.W., and W.S.W.—*i.e.*, sixteen distinct points of the compass. Piercing these sixteen sides and entering the lantern-room, are fifteen round ventilators and the balcony door, any of which can be opened or shut for ventilation by the keeper on watch, according to the wind. Outside on the balcony, by standing with one's back to the lee-side, the direction of the wind can be accurately ascertained, the greater pressures being right and left of the sixteenth side, which is MOST sheltered; and even in very high winds this can with accuracy be fixed." The accompanying diagram on next page will perhaps assist in explaining my meaning. (For an illustration of the above, see under the species,[1] Gold-crested wren, in the list of species.)

Further, in connection with the faunal position of the Isle of May and the conditions of its migratory fauna, the additional note seems valuable, viz.: that "The North Star,

[1] Which list it is intended will be given in a future paper, and which was read at the meeting of the Society held on the 15th December 1886.

above the two outer pointers of the Plough on a starry night about the middle of October, and the light of the lantern of the lower lighthouse, coincide, and are about due magnetic north."[1] Further: "The village of Crail on the Fife coast, and the east wall of the lighthouse, *line* together, as nearly as possible—and probably exactly—due north and south. Bell Rock Lighthouse is visible from the North of



briefly to notice a few of the more prominent features. This, along with the admirable 6-inch-to-the-mile Ordnance Survey Map, ought to prove sufficient for practical purposes.

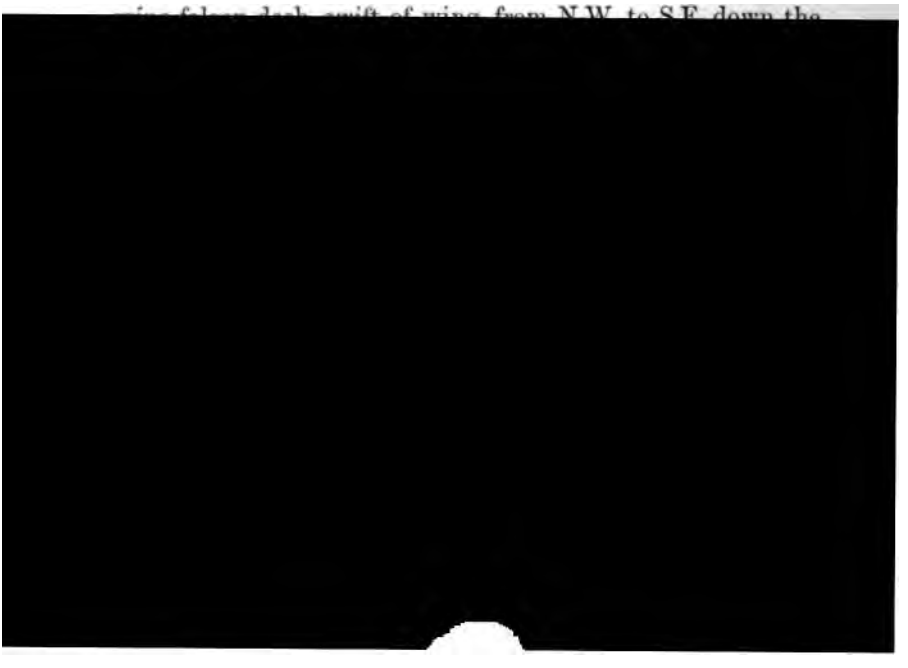
The peninsular portion to the north of *The Pool* (*vide* Map) and between that and *The North Ness* is rugged, bare, and often spray-washed; rocky, with deep gyös or water-channels, having a few green patches of shallow sea-pink soil on some of the higher portions. Often, amongst the crevices and shelter-giving hollows of these splintered and weather-beaten rocks, a friend and myself lay ensconced, and took stock of Cormorant or Sea-gull, or passing migrant, such as the Hooded crow, or watched the active Merlin dash, swift as thought, amongst a flock of shore-birds. On this stretch the Oystercatcher breeds, selecting for its nesting site the slightly grassy eminences; and Terns are reported to have bred in former times. Only during extremely high tides is this low North-Ness portion separated from the rest of the island, and never, as far as I could learn, is it so completely isolated as to prevent passage on foot across the two narrow gyös on either side of a small island, which is marked on the map.

Another section of the island, between that which I have just mentioned and the narrow lochs or arms of the sea marked on the map as East and West Tarbet, is more elevated, greener, and contains deeper soil. Here rabbits have their burrows, and Eider ducks breed in small numbers.

The central portion of the Isle of May, which may be said to rise rapidly southwards from the Tarbet lochs past the landing-place called "The Altarstones," and of which the lighthouse occupies one of the two or three highest points,—reaching in altitude 250 feet above sea-level,—is richer still in loam and grazing, growing many fine and richly-flavoured mushrooms, of which delightful esculent we had daily supplies the whole time we were there in September and October 1884. Over this, as in lower portions also, Woodcock at times are common, sheltering provokingly close behind a jutting rock, or even beneath the shelter of the rougher grasses in the hollows; and here rabbits are *most* abundant, but wary and quick in their movements.

The fourth, or most southern part of the Isle of May, is

separated by a deep glen or hollow from the lighthouse portion, which hollow runs in a N.W. and S.E. direction from the "Mill Door," already mentioned, to the Kirkhaven. This part, at one place equal in height to the site of the lighthouse, slopes away to the South Ness, running out to the cliff-edge with an elevation of about 50 feet. It comprises the semi-artificially-formed and confervæ-inhabited lakelet, the farm-buildings of the station, the cultivated fields to the southward, the well and pump therewith connected, the Kirkhaven, the Chapel and Priory, the Ladies' Well and Cave, the curious isolated rocks called "The Pilgrims," the outlying skerries of the "Maiden's Hair" and "Maiden's Bed," and the east coast pier and landing-place of the island. There is also a deep depression, which runs round the east side of the island, called on the map "Holyman's Road," over which the path which leads to the lower lighthouse crosses by a substantially-built bridge. It is amongst these hollows and fields and stone-walled enclosures that many land birds on migration must be looked for. Often we saw flocks of Linnets, Larks, and Thrushes skim over the south wall of the cornfields, and drop for shelter in the potatoes or stubbles, or shot the Jack or Common snipe out of the scanty cover afforded by the *débris* of stones near the old Priory, and saw the bold Pere-



One other feature, which scarcely can escape the observation of even the most casual observer, is the great number of round sea-pink-covered mounds, about a foot in height, which cover large portions of the island, and which are perhaps specially numerous on the south portion. Red ants are extremely abundant, in fact, swarming over the greater part of the island, and these innumerable mounds are the ant-hills thrown up and inhabited by very many generations of ants, which, fortunately for the enjoyment of other life on The May, do not bite. I am told there are also a few black ants on the island, but in September and October we saw nothing of these. Turn over a stone almost anywhere on the grassier parts of the island, and there will be found a colony of red ants. In a certain period of time these loose stones will be covered over with finely pulverised earth, thrown up, or rather carried up, from the ground by the busy workers. Upon this finely pulverised soil the sea-pink seems fond of seizing hold, and most of the older hills are covered with its close leafage.

In an interesting paper on "The Isle of May," by Mr J. Rattray, in the *Dundee Herald*, that gentleman tells us that experiments had been tried by the Commissioners to extirpate the ants, owing to the damage, it was alleged, they were doing to the pasturage. Quicklime, put deep into the mounds, failed to have any appreciable effect; then carbolic acid, though killing many, also failed signally; then ammonial lime was tried equally ineffectually; lastly, two men were steadily employed for a week digging into the ant-hills. A proposal to rip them up with a plough, scatter the contents, and throw them open to the frost and rain, was not followed out.

The common Land snail (*Helix aspersa*) occurs, but not so abundantly, apparently, as on the Bass Rock, and other places I have visited. We were unable to find any other land- or fresh-water molluscs, but we had not proper instruments for examining the brackish and green, confervæ-laden water of the lake.

It now remains for me to *record* the breeding species of the bird-fauna of the Isle of May, bringing the list up to

the latest dates available.[1] Future years may, and, I believe, undoubtedly will, develop many more interesting data, especially if we always obtain the assistance of such careful, painstaking, and deeply-interested observers as Mr Joseph Agnew, late head-lighthouse-keeper at the Isle of May; and of such men as Mr Robert Clyne, now stationed at Isle of Man, who has sent us many valuable records already from that station, and who had previously assisted Mr Agnew as under-keeper at the Isle of May. I could mention many others, equally interested, at other stations, but there will be, I hope, opportunities of treating of the faunal positions of some of these stations before long.

I give a list, with notes, upon the birds found breeding on the Isle of May.

List of, and Notes on, the Birds found Breeding on the Isle of May.

The Blackbird, *Turdus merula*.—Breeds regularly, in small numbers, in the ruins of the Priory, on the ground, in a bunch of nettles, in the corners of walled-in enclosures, and in holes in walls. A few apparently resident, most, if not all, of the year. Many additions of passing migrants in autumn. Rarer on spring migration. Decided rush in spring

larly, but cannot be regarded as resident. Also a passing migrant. Is increasing annually in the breeding season.

Wheatear, *Saxicola œnanthe*, L.—Breeds regularly and abundantly. Mr Agnew reckons their numbers at about fifty pairs on the island. Great accessions in autumn, and tolerably regular spring bird of passage, though in some years there are very few records.

Meadow Pipit, *Anthus pratensis*, L.—Breeds regularly, and not uncommonly. Great accessions of passing migrants in autumn, and also regular in spring.

Rock Pipit, *Anthus rupestris*, L.—Resident. Breeds very commonly; perhaps the commonest bird in the Isle of May at all seasons. Great accessions in spring and autumn.

Pied Wagtail, *Motacilla Yarrellii*, L.—Four or five pairs breed; also a rare spring visitant, and commoner in autumn.

Common, Grey, or Rose Linnet, *Linota cannabina* (L.).—A few pairs breed annually, and there was visible increase in 1884. Vast migrations take place.

Hedge Sparrow, *Accentor modularis*, L.—Bred for the first time in 1884, and reared two broods. I saw the site of the second nest in October 1884, which was pointed out to me by the Agnews.

Eider Duck, *Somateria mollissima*, L.—Breeds annually, but in annually decreasing numbers owing to persecution. In 1880 we found an empty nest one day in June; and a tourist carried off a clutch of eight eggs the same day, which he had found near the south end of the island. They breed often at considerable heights above the sea, and distant from the water. It would be well if something could be done for their protection, as they are rapidly becoming scarcer on the islands of the Firth of Forth. There is one nest on the Bass Rock (there is no need to conceal the fact, as alas! it is already too well known). During two years since the new lighthouse on Fidra was commenced, and which was lighted for the first time in April 1884, they naturally left that site, but have again returned, as no guns are allowed to be used on this island.

Obs.—Of the Terns we saw nothing in 1880. Mr Agnew, who knows Terns well, says he never found any species

breeding on the Isle of May. Mr Robert Gray lately spoke of their existence there, but it seems to be exceedingly doubtful that they have bred for years back. Neither Common, Arctic, nor Roseate terns occur now (1884), though the latter is spoken of by Mr Gray as at one time occurring there. Indeed, it is only very rarely that the Isle of May is ever visited by Terns, even on migration. The only one ever caught at the lantern was one in 1879, but they are of course seen out at sea.

RAZORBILL, *Alca torda*, L.—Not very abundant, though Mr Agnew speaks of them during some seasons as being in hundreds. I saw very few in the "height of the season" in 1880. Indeed, there appear to be very few nesting sites such as they delight in—few broad ledges, a few creeks and crannies and rents in the cliff face, but scarcely likely-looking to hold hundreds nesting.

COMMON GUILLEMOT, *Uria troile*, L.—Fairly abundant, and I believe as many as the cliff face and ledges afford foot-hold and nesting sites for. More numerous than on the Bass Rock. I saw a few, but very few, of the bridled variety in 1880. Mr Clyne shot five Guillemots at a shot one day, one of which was bridled, but this cannot be taken as an average.

KITTIWAKE, *Rissa tridactyla*, L.—Common at the S.W. and

or to have frequented the island regularly. It also bred formerly on the Bass Rock.

CORMORANT, *Phalacrocorax carbo*, L.—A few pairs breed; and they are common on the Isle of May, using the higher parts of the cliffs as roosting-places, and fishing in the neighbourhood all the year round. About fifty pairs formed the winter colony in 1884. Most abundant in winter. Movements local and not regularly taken note of. So long ago as 1828 this cormorancy in winter was taken note of, and even then "a few" are noted as remaining to breed (*Edin. New Phil. Journ.*, vol. vi., p. 190—"Zoology").

SHAG, *Phalacrocorax cristatus*, L. — Common breeding species, but scarcer in the autumn, and much scarcer than the last-named species at that season.

XXII. *Note on the Water Vole* (Arvicola amphibia, *Jenyns*). By Professor DUNS, Vice-President.

(Read 16th March 1887.)

On the 21st of April 1880 I read a short paper to the Society on the Water Vole, in connection with two specimens which seemed to present exceptional aspects of habit. One of these had made a "run," and had thrown up mole-like "hills" in a grass plot of the late Rev. Walter Wood's garden, Elie, Fife. The other had been trapped in the garden, 14 Hope Terrace, Edinburgh. The specimen referred to in this paper was captured in Dr Ronaldson's garden, 18 Bruntsfield Place, Edinburgh, and handed to me by Mr Evans, a fellow of the Society, on the 4th of this month. The Elie garden is near the shore of the Firth of Forth. The water nearest Hope Terrace is the Jordan Burn, on the north side of Blackford Hill, about a quarter of a mile distant, and Bruntsfield Place is about the same distance from the Union Canal. In each case the animal had wandered a considerable distance from its usual haunts, and taken up its abode in places whence it could have no ready access to water. The Elie specimen was not known to have done damage to any plants in the garden. The contents of the stomach were grass root-

lets and fragments of clover leaves. The "runs" of the Hope Terrace specimen were among plots of beetroot, to which it had done much damage, and on which it had been feeding. It was found that the *viscera*, and even the body walls and parts of the under surface of the skin, were stained by the bright red juice of the beet. After lying nearly six years in methylated spirit, the dye continues still well marked. The Bruntsfield Place specimen was an old male. On examination, I found the stomach crowded with tiny, thin shavings of almost dry wood, and the intestines filled with a clear, lightish-brown watery fluid, containing granular particles, which, under the microscope, were seen to be fragments of wood fibre. The animal had been burrowing at the roots of bushes and sapling apple trees, and had destroyed several.

The first specimen was sent to me in summer, the second in autumn, and the third in spring. The following passage from Gilbert White's "Selborne" may be quoted in this connection:—"As a neighbour was lately ploughing in a dry chalky field, far removed from any water, he turned out a water rat that was curiously laid up in a hybernaculum, artificially formed of grass and leaves. At one end of the burrow lay about a gallon of potatoes, regularly stored, on which it was to have supported itself for the winter. But

Up to a very recent date, if not even yet, a good deal of ignorance prevailed as to the habits of the Water Vole, but, as corrective of this, we may hold the following points made out:—1. This animal is frequently found in localities at a considerable distance from water. 2. Like the Mole, it burrows and throws up heaps at short distances in its run. 3. It does not eat worms, nor small fishes. 4. It is wholly a vegetable feeder, and its food does not consist solely of succulent water plants; on the contrary, it is known to eat potatoes, beet, the leaves of clover, grass rootlets, the roots and root tendrils of shrubs, and of apple, plane, and oak saplings. 5. When it attacks the bark, it does so close to, or just below, the surface of the soil.

In my previous paper I referred to the black variety of Water Vole (*Arvicola ater*, Macgil.) as at that time often met with in Aberdeenshire; and, on the authority of Mr Gray, as at one time common in the neighbourhood of Dunbar. I now learn that in the former locality it is rare, while in the latter, a keen observer, Mr Hardy, of the Berwickshire Naturalists' Club, writes that he has long "had a sharp eye for black varieties, but none have been apparent." In the Club's "Proceedings," the occurrence of three specimens is recorded, and in each instance it is said, "they were not so large as the common Water Vole." The specimen of the black variety on the table belonged to my predecessor in the Natural Science Chair, New College, Professor John Fleming. The label attached to it, "*Arvicola aquatica*, Aberdeen," is in his own writing. Laying it alongside of the two specimens of the common form, it is seen to be much larger than either. It is more than an inch longer than the measurement given by Bell of the common sort, and must have been in all respects larger than those now on the table.

XXIII. *The Echinodermata of the Firth of Clyde.* By J. R. Henderson, Esq., M.B., F.L.S., Professor of Biology, etc., in the Christian College, Madras; Fellow of the University of Madras.

(Read 15th December 1886.)

[A manuscript, consisting of notes on the occurrence of Echinodermata in the Firth of Clyde, was put into my hands in November 1885 by my friend, Professor J. R. Henderson, with the request that I would revise the names and communicate the paper for him to this Society. The notes were compiled from observations made during the dredging operations of the yacht "Medusa," of the Scottish Marine Station, in the estuary of the Clyde, during the summer of 1885, and were supplemented by information communicated to Professor Henderson by other naturalists. Last winter I was unable to finish the preparation of these notes for publication, but have now revised the nomenclature as follows:— The names of the Crinoidea are those given by Dr Norman in his paper "On the Genera and Species of British Echinodermata;"[1] for the Ophiuroidea, I have followed Mr W. E. Hoyle's "Revised List of British Ophiuroidea," in Vol. VIII. of the *Proceedings* of this Society; for the Echinoidea, I have

Order I.—CRINOIDEA.

Antedon rosaceus, Norman (Linck).

Comatula rosacea, Forbes, Brit. Starfishes, 1841.
Antedon rosaceus, Norman, Ann. and Mag. Nat. Hist. (3), xv., 1865.

Common on hard ground (10-20 fathoms) throughout the district. Especially common off the south end of Bute (Callum's Hole and Hank's Neb), and off the west side of Little Cumbrae. Off Roseneath Point.

Antedon Milleri, Norman (Müller).

Antedon Milleri, Norman, *op. cit.*

Arran (Prof. Wyville Thomson).

Order II.—OPHIUROIDEA.

Ophiothrix pentaphyllum, Ljungmann (Pennant).

Ophiocoma rosula, Forbes, Brit. Starf.
,, *minuta*, Forbes, *op. cit.* (the young).
Ophiothrix pentaphyllum, Ljn., Öfvers. k. Svensk. Akad. Förhandl., 1871.

Abundant in all parts of the Firth from low water down to considerable depths on hard ground.

[The name given for this species by Dr Henderson was *Ophiothrix fragilis*, O. F. Müller, with *Ophiocoma rosula*, Forbes, and *Ophiocoma minuta*, Forbes (the young), as synonyms. Thus Dr Henderson, like Forbes and Norman, has not distinguished between the species *O. pentaphyllum* and *O. fragilis;* and therefore the above distribution only applies to the two species taken as one.—J. T. C.]

Amphiura elegans, Norman (Leach).

Ophiocoma neglecta, Forbes, Brit. Starf.
Amphiura elegans, Norman, *op. cit.*
Amphipholis elegans, L. & K., Vidensk. Meddel., 1871.
,, *Kinbergi*, Ljn., Öfvers. k. Svensk. Akad. Förhandl., 1871.
,, *oppressa*, *Id.*, *op. cit.*
,, *lineata*, *Id.*, *op. cit.*
Amphiura neglecta, Herdman, Proc. Roy. Phys. Soc., Edinb., vol. v., 1880.
,, *squamata*, Leslie and Herdman, *op. cit.*, vol. vi., 1881.
,, ,, Lyman, Zool. Chall. Exp., pt. xiv., 1882.

Common under stones at low water mark.

AMPHIURA CHIAJII, Forbes.

Amphiura Chiajii, Forbes, Trans. Linn. Soc., vol. xix.
Ophioconna punctata, Forbes, Brit. Starf. (the young ?).

Firth of Clyde (Norman). Common in mud throughout the district. Off Ascog Point, 11-15 fathoms, mud. Loch Striven, 40 fathoms, mud. Kilchattan Bay, 20 fathoms. Off Tarbert, Loch Fyne, 25 fathoms. Off north-west end of Little Cumbrae, 60 fathoms, mud, rare. Kilbrennan Sound, 75-80 fathoms. Loch Long, opposite mouth of Loch Goil, 35 fathoms, mud, abundant. Loch Long, below junction with Loch Goil, 45 fathoms, mud, abundant. Skelmorlie Bank, 5-16 fathoms, shells and stones. It is a larger and decidedly less fragile species than *A. filiformis*.

AMPHIURA FILIFORMIS, Forbes (O. F. Müller).

Ophiocoma filiformis, Forbes, Brit. Starf.
Amphiura filiformis, Forbes, Trans. Linn. Soc., Lond., vol. xix., 1843.

Rothesay Bay and Gair Loch (Forbes). Firth of Clyde (Norman); not uncommon in mud down to considerable depths. First taken in Britain by Forbes in Rothesay Bay, July 1839. Off Ascog Point, 11-15 fathoms, mud. Mouth of Loch Fyne, 100 fathoms, mud. Off Skelmorlie Point, 39 fathoms, common. Off north-west end of Little Cumbrae, 35

OPHIACTIS BALLII, Lütken (Thompson).

Ophiocoma Goodsiri, Forbes, Brit. Starf.
Ophiactis Ballii, Ltk., Addit. ad Hist., pt. 2, 1859.

Clyde (David Robertson). Off Cumbrae.

OPHIOPHOLIS ACULEATA, Lütken (O. F. Müller).

Ophiocoma bellis, Forbes, Brit. Starf.
Ophiopholis aculeata, Ltk., Addit. ad Hist., pt. 1, 1858.

Common on hard ground from low water to considerable depths. It is decidedly the least fragile of the British Ophiurids, and perfect specimens are easily obtainable. When taken from the water it usually coils the arms in on the disc. Off Inellan the dredge came up almost full of Ophiurids, nearly all of this species. At mouth of Loch Goil, hard ground, this species almost filled the dredge.

OPHIOGLYPHA LACERTOSA, Lyman (Pennant).

Ophiura texturata, Forbes, Brit. Starf.
,, *lacertosa*, Norman, *op. cit.*
Ophioglypha lacertosa, Lyman, Ill. Cat. Mus. Comp. Zool., No. 1, 1865.

Not uncommon on moderately hard ground (stones, shells, and Melobesia). Off Cumbrae, especially on Tan Spit. Off south end of Bute. Off Portincross Point, 12 fathoms. Loch Striven. Loch Goil, very fine specimens.

OPHIOGLYPHA ALBIDA, Lyman (Forbes).

Ophioglypha albida, Lyman, Ill. Cat. Mus. Comp. Zool., No. 1, 1865.
Ophiura albida, Forbes, Brit. Starf.
,, ,, Norman, *op. cit.*

Abundant on gravelly and hard ground in all parts of the Firth.

OPHIOGLYPHA AFFINIS, Lyman (Lütken).

Firth of Clyde, 20-40 fathoms (Norman). Loch Fyne, not uncommon on hard and gravelly ground, 15-40 fathoms. Kilbrennan Sound, 75-80 fathoms, not uncommon.

Order III.—ASTEROIDEA.

Astropecten irregularis, Norman (Pennant).

Asterias aurantiaca, Forbes, Brit. Starf.
Astropecten irregularis, Norman, *loc. cit.*

Not common. Skelmorlie Bank. Off Cumbrae. Off Ardrossan. Off Portincross Point, 20 fathoms, common. Occasionally plentiful in sand at low water, Cumbrae (David Robertson). Loch Goil, 5½ fathoms, hard ground. A specimen taken on the Skelmorlie Bank had the stomach packed with shells of *Natica Montacuti* and *Venus ovata*, 47 being extracted.

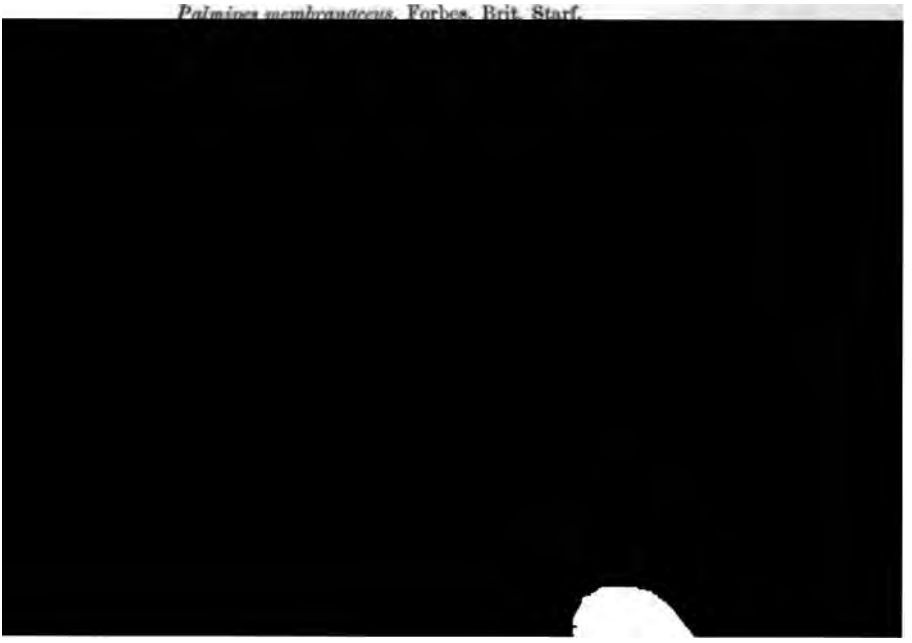
Luidia Savignii,[1] Müll. and Tr. (Audouin).

Luidia fragilissima, Forbes, Brit. Starf.
,, *Savignii*, Müll. and Trosch., Syst. der Aster., 1842.

Firth of Clyde (Norman). Arran (W. C. Trevelyan). Lamlash Bay, not uncommon. Off Cumbrae, especially on Zostera beds, not common (David Robertson).

Palmipes membranaceus, Norman (Linck).

Palmipes membranaceus, Forbes, Brit. Starf.



CROSSASTER PAPPOSUS (Link.), Müll. and Tr.

Solaster papposa, Forbes, Brit. Starf.

Common in all parts of the Firth from low water to 20 fathoms.

SOLASTER ENDECA (Gmel.), Forbes.

Solaster endeca, Forbes, Brit. Starf.

Not uncommon in shallow water. Off Cumbrae. Off Dunoon. Lamlash Bay. Skelmorlie Bank. Loch Goil. Abnormalities in rays frequent.

PORANIA PULVILLUS (O. F. Müller), Norman.

Goniaster Templetoni, Forbes, Brit. Starf.

Not uncommon. Off Cumbrae. Off Callum's Hole, Bute. Lamlash Bay. Skelmorlie Bank, very fine specimens.

CRIBRELLA OCULATA (Linck), Forbes.

Cribella oculata, Forbes, Brit. Starf.
Cribrella sanguinolenta, Lütken, Oversigt over Grönlands Echinodermata, 1857.

Common between tide marks, and in shallow water. Loch Goil.

STICHASTER ROSEUS (O. F. Müller), Müll. and Tr.

Cribella rosea, Forbes, Brit. Starf.
Stichaster roseus, Sars, Oversigt af Norges Echinodermer, 1861.

Lamlash Bay (Dr Miles *et nobis*). Off Holy Island. Off Tan Buoy, Cumbrae, rather rare, 20-30 fathoms (David Robertson *et nobis*).

ASTERIAS GLACIALIS, Linnæus.

Uraster glacialis, Forbes, Brit. Starf.

Common in the Laminarian zone and shallow water. Lamlash Bay. Off Cumbrae. Off Callum's Hole, Bute. Off Portincross Point, 15 fathoms. Frequently occurs on Zostera beds, Cumbrae (David Robertson).

ASTERIAS RUBENS, Linnæus.

Uraster rubens, Forbes, Brit. Starf.

Abundant between tide marks and in shallow water.

ASTERIAS VIOLACEA, O. F. Müller.

Uraster violacea, Forbes, Brit. Starf.

Common in shallow water with *A. rubens*.

ASTERIAS HISPIDA, Pennant.[1]

Uraster hispida, Forbes, Brit. Starf.

Kyles of Bute, under stones on the shore (Forbes). Cumbrae at low water, rare (David Robertson).

Order IV.—ECHINOIDEA.

ECHINUS ESCULENTUS, Linn.

Echinus sphaera, Forbes, Brit. Starf.

Abundant between tide marks, and in the Laminarian and Coralline zones.

ECHINUS MILIARIS, P. L. S. Müller.

Clyde, as off the island of Cumbray, in Rothesay Bay, and the Kyles of Bute, in which places I met with it for the first time in July 1840" (Forbes, "Brit. Starf.," p. 188).

ECHINOCARDIUM CORDATUM (Penn.), Gray.

Amphidotus cordatus, Forbes, Brit. Starf.

Common in sand at low water, and dredged in sandy ground in shallow water.

ECHINOCARDIUM PENNATIFIDUM, Norman.

Firth of Clyde, off Cumbrae, a single specimen (David Robertson).

ECHINOCARDIUM FLAVESCENS (Müller), A. Agassiz.

Amphidotus roseus, Forbes, Brit. Starf.

Loch Striven, 30-40 fathoms, mud. Off Garnock Beacon, 35 fathoms. Skelmorlie Bank, 5-16 fathoms. Not uncommon in deepish water.

SPATANGUS PURPUREUS, O. F. Müll.

Off Cumbrae, not uncommon. Skelmorlie Bank, common. Lamlash Bay. Off Garnock Beacon, 35 fathoms. In sand at low water at Little Cumbrae, a single specimen (David Robertson). Frequently with *Montacuta substriata*.

ECHINOCYAMUS PUSILLUS (Müll.), Gray.

Off Cumbrae. Skelmorlie Bank. Lamlash Bay. Common, especially on a Nullipore bottom.

Order V.—HOLOTHUROIDEA.

PSOLUS PHANTAPUS (Strussenfeldt), Jäger.

Psolus phantapus, Forbes, Brit. Starf.

Gair Loch, opposite Helensburgh, 10 fathoms (Forbes *et nobis*). Kilchattan Bay. Off Callum's Hole, Bute. Off Tarbert, Loch Fyne, 40 fathoms. In these cases small specimens. Off Cumbrae rather rare, dredged, and on lines; some

fine specimens (David Robertson). Skelmorlie Bank. Loch Goil, 6-10 fathoms.

Cucumaria elongata, D. & K.

"I have dredged many of all varieties in the Firth of Clyde. In the Gair Loch it is abundant in about ten fathoms water" (Forbes). Abundant in Campbelltown Loch, 7 fathoms mud. Under stones at Allans at extreme low water.

Cucumaria Hyndmanni (Thompson), Forbes.

Not uncommon on hard ground. Off Cumbrae. Lamlash Bay (Herdman). Kilbrennan Sound, 75-80 fathoms. Loch Fyne, on gravelly and shelly ground, adhering usually to old shells. Skelmorlie Bank.

Cucumaria brunnea (Thompson), Théel.

Ocnus brunneus, Forbes, *op. cit.*

Firth of Clyde, common (Forbes). Lamlash Bay, 20 fathoms (Herdman). On Laminaria at Tan Buoy (David Robertson).

THYONIDIUM DRUMMONDII (Thompson).

Thyonidium commune, Forbes & Goodsir.
Cucumaria communis, Forbes, Brit. Starf.

Off Portincross a single specimen, 6-10 fathoms, Sept. 1885.

SYNAPTA DIGITATA (Montagu), Müll.

Chirodota digitata, Forbes, Brit. Starf.

Abundant at low water in a sandy bay near the Castle, Little Cumbrae. At low water, spring tides, between the Allans, but rare (David Robertson).

SYNAPTA INHÆRENS (O. F. Müll.), Rathke.

Lamlash Bay, 20 fathoms (Herdman). Cumbrae, at low water, among Zostera, and between Allans (David Robertson).

SYNAPTA TENERA, Norman.

Firth of Clyde, not uncommon in mud, 15-40 fathoms (Brady and Robertson). Between Largs and Cumbrae. Ardentinny. Loch Goil and Loch Long. Off Little Cumbrae.

XXIV. *List of Shells collected by* Mr JOHN RATTRAY, B.Sc., F.R.S.E., *on the West Coast of Africa and the adjacent Islands.* By WILLIAM E. HOYLE, Esq., M.A. (Oxon.), F.R.S.E., Correspondent of the Academy of Sciences of Philadelphia.

(Read 19th January 1887.)

The shells enumerated in the subjoined list were collected by Mr John Rattray during the recent cruise of the telegraph ship "Buccaneer." That the number is not much larger must be attributed to the short time spent at each calling place, as well as to the fact that his attention was directed to the flora rather than to the fauna of the district. A considerable quantity of surface collections were made at

different times on the cruise, and it is likely that when these have been completely investigated they will yield some interesting pelagic forms. The identifications have all been verified by comparison with specimens in the British (Natural History) Museum at South Kensington; and I desire here to acknowledge the valuable assistance obtained from the Conchological Department in that part of the work.

Mr Rattray has been good enough to furnish me with the following notes upon the various localities at which his collections were made :—

"*Accra*, visited on January 16, 1886, presented an undulating, barren, sandy, and spray-beaten beach, lying to the east of the town, which yielded but few specimens. Marine Algæ were scarcely represented in this locality; even the steep sandstone cliffs, up to the bottom of which the sand extended, though lashed continually by a dense spray of seawater, were found perfectly barren. Fragments of cuttle-bones were not uncommon on the beach.

"*San Thomé Island*, near the head of the Gulf of Guinea, was visited on January 25 and 31, and on February 1, 1886. The low volcanic boulders, extending from the fortress towards the penal establishment, and separating the marshy ground lying just outside the town from the sea, yielded the

"*St Paul de Loanda*, on the east coast of the Gulf of Guinea, was visited from February 10 to 17, 1886. The majority of the shells were found on the small island opposite the town, and separating the anchorage from the ocean. This island consists exclusively of sand; it is low throughout, and will no doubt soon become united to the mainland at one, at least, of its ends, on account of the immense quantity of sand yearly carried down to the anchorage from the soft sandstone, or sandy cliffs, in the vicinity of and behind the town. Near the coaling jetty, on the mainland, a few specimens were got, and a few more were also dredged in shallow water in the anchorage, being brought up with large masses of Zoophytes. Most of the specimens were found dry on the seaward face of the island just referred to, where remarkable undulations of the sand, similar to what may be seen in miniature on a sandy beach on our own coasts, form dune-like masses, standing almost at right angles to the coast.

"*Porto Praya, Cape Verde Islands.*—A call was made here on the homeward voyage, in March 1886, but only a few shells were gathered at the base of the richly fossiliferous cliffs surrounding the bay opposite the town. A large number were, however, purchased from a native, by whom they had been gathered in the neighbourhood; but on examination, these were found to have been selected rather with respect to size and elegance than with the object of procuring the greatest variety of forms.

"*Gran Canaria.*—The remarkable isthmus connecting the isleta to the main island was examined for a few hours on December 13, on the outward passage. Near the water-level it was found to consist of soft, richly fossiliferous sandstone, which readily crumbled even on slight pressure. Imbedded shells were found belonging to the same species as were found living on the beach in the immediate vicinity, where Helices, Cones, and Cerithia were not unfrequent."

GASTROPODA.	African Coast.						Gran Canaria.	Porto Praya, Cape Verde Is.
	Accra.	Conakry.	Dakar.	Loanda Island.	Principe Island.	San Thomé.		
1. Helix undata, *Love*,							*	
2. ,, Glasiana, *Shuttleworth*,							*	
3. ,, pisana, *Müller*,							*	
4. Achatina bicarinata, *Dillwyn*,					*			
5. Siphonaria venosa, *Reeve*,	*	*						
6. Bulla ampulla, *Linné*,		*				*		*
7. Terebra senegalensis, *Lamarck*,				*				
8. Conus testudinarius, *Martini*,						*		
9. ,, guinaicus, *Hwass*,			*				*	
10. ,, Prometheus, *Hwass*,			*		*			
11. ,, sp. incert.,								*
12. Cancellaria cancellata, *Linné*,				*				
13. ,, similaris, *Sowerby*,		*						
14. Oliva hiatula, *Gmelin*,	*		*					
15. ,, flammulata, *Lamarck*,				*				
16. Harpa rosea, *Lamarck*,								*
17. Marginella glabella, *Linné*,		*						
18. ,, amygdala, *Kiener*,			*					
19. Cymbium olla, *Linné*,			*					
20. Mitra sp. incert.,								*
21. Melongena morio, *Linné*,	*		*		*			
22. Tritonidea variegata, *Gray*,						*	*	*
23. Nassa conspersa, *Philippi*,							*	
24. Dorsanum vitreum, *Reeve*,		*						
25. Columbella reticulata, *Lamarck*,			*			*	*	
26. Mitrella cribraria, *Lamarck*,			*					
27. Murex rosarius, *Chemnitz*,						*		
28. ,, turbinatus, *Lamarck*,					*			
29. ,, sp. incert. (*near* M. regius, *Wood*),			*					
30. Purpura hæmastoma, *Linné*,		*	*			*	*	*
31. ,, cruentata, *Lamarck*,								*
32. ,, neritoïdea, *Linné*,						*		*
33. ,, bufo, *Lamarck*,	*							

GASTROPODA.	African Coast.						Gran Canaria.	Porto Praya, Cape Verde Is.
	Accra.	Conakry.	Dakar.	Loanda Island.	Principe Island.	San Thomé.		
61. Scalaria pseudoscalaris, *Risso*,							*	
62. Obeliscus dolabratus, *Linné*,				*				
63. Nerita atrata, *Chemnitz*,		*	*			*		*
64. Trochus (Gibbula) cicer, *Menke* (?),						*		
65. ,, (Clanculus) guinaicus, *Chemnitz*,	*							
66. ,, ,, tristis, *Gray*,						*		
67. ,, (Oxystele) Saulcyi, *d'Orbigny*,							*	
68. Haliotis tuberculata, *Linné*,						*		
69. Fissurella obtusa, *Sowerby*,						*		
70. ,, rosea, *Lamarck*,	*							
71. ,, sp. incert. (*near* F. Rüppelli, *Sow.*),						*		
72. ,, sp. incert.,		*						
73. Patella capensis, *Gmelin*,		*						
74. ,, plumbea, *Lamarck*,		*						
PELECYPODA.								
75. Ostrea Forskali, *Chemnitz*,								
76. Spondylus unicolor, *Sowerby*,						*		
77. Pecten concentricus, *Say*,						*		
78. Avicula sp. incert. (*near* A. argentea, *Reeve*),		*				*		
79. Isognomon nucleus, *Lamarck* (?),						*		
80. ,, sp. incert.,						*		
81. Mytilus plicatulus, *Lamarck*,			*			*		
82. Arca senilis, *Linné*,			*	*		*		
83. ,, decussata, *Sowerby*,						*		
84. ,, domingensis, *Lamarck*,						*		
85. ,, Noæ, *Linné*,			*			*		*
86. ,, sp. incert.,				*				
87. Pectunculus formosus, *Reeve*,						*		
88. Cardita senegalensis, *Reeve*,						*		
89. ,, sinuata, *Lamarck*,	*							
90. Crassatella contraria, *Lamarck*,						*		
91. Lucina leucoma, *Turton*,				*				
92. ,, (Codakia) pecten, *Lamarck*,						*		
93. Chama ruderalis, *Lamarck*,			*					
94. ,, senegalensis, *Reeve*,		*						
95. Cardium pectinatum, *Linné*,						*		
96. ,, rusticum, *Linné*,				*				
97. ,, tuberculatum, *Lamarck*,	*							
98. Venus plicatula, *Chemnitz*,	*							
99. ,, verrucosa, *Linné*,								*
100. Cytherea (Caryatis) tumens, *Gmelin*,		*						
101. Dosinia exoleta, *Linné*,				*				
102. ,, Orbignyi, *Dunker*,				*		*		
103. Semele modesta, *A. Adams*,	*					*		
104. Tellina complanata, *Chemnitz*,	*							
105. ,, madagascariensis, *Gmelin*,				*				
106. ,, umbonella, *Lamarck*,	*							
107. ,, (Macoma) cumana, *Da Costa*,			*					
108. Donax rugosus, *Linné*,	*			*				
109. Mactra Adansoni, *Philippi*,								*
110. ,, Largillierti, *Philippi*,	*			*	*	*		*
111. Solen guineensis, *Spengler*,					*			
112. Tagelus gibba, *Spengler*,						*		

The following species simply bore the label, "West Coast of Africa":—
Stenogyra terebraster, *Férussac.* Oliva flammulata, *Lamarck.*
Trochus turbinatus, *Born.*

XXV. *On the Development of the Oviduct in Teleosteans.* By J. T. CUNNINGHAM, Esq., B.A., F.R.S.E.

(Read 20th April 1887.)

In Balfour's "Comparative Embryology" (vol. ii., 1881 p. 605), the question of the morphological nature of the genital ducts in *Teleostei* was left undecided, but it was argued that the fact that the Müllerian ducts of the Teleostean Ganoid *Lepidosteus* attach themselves to the generative organs, and thus acquire a resemblance to the generative ducts of *Teleostei*, afforded a powerful support of the view that the generative ducts of both sexes in the *Teleostei* were modified Müllerian ducts. Subsequent inquiries showed, however, that the Müllerian ducts did not in *Lepidosteus* attach themselves to the generative organs, and no connection can be traced between Müllerian ducts and generative organs in the development of Teleosteans. An attempt to follow out the development of the Teleostean oviduct was made by a Belgian embryologist in 1881.[1] He was successful in finding indications of the origin of the duct in only one species—*Belone acus*. He found in embryos of this species 54 mm. long, that the genital ridge projected far into the body cavity, its base of attachment being narrow, so that in transverse

beneath the urinary vesicle, the coalescence of these prolongations together, and the formation of an opening to the exterior.

The size of the furrow and tube in *Belone acus*, according to the figures of MacLeod, bears a very small proportion to the size of the whole genital ridge. The state of things which I have observed in the young sprat is somewhat different. The genital ridge in all *Teleostei*, as MacLeod observes, is very late in developing; in an alevin of *Salmo Levenensis* three days after hatching, the structure can be by careful scrutiny made out as a few rather conspicuous cells in the peritoneal epithelium. In *Clupea sprattus* I was unable to find indications of the formation of the ovarian tube in young fish under the length of 5 cm. In specimens of that size, when cut into a series of transverse sections, the ovary is seen to be already tubular in the anterior portion, while posteriorly the tube is incomplete and open. The tubular ovary has a large cavity; the whole of the mediad and of the ventral wall is very thick, consisting of a mass of young ova; the other parts of the wall are thinner, a rather thick epithelium extending from the germinal region round the rest of the inner surface of the tube, while the external surface of the ovary is formed by a layer of fibrous connective tissue covered by endothelium. Posterior to the ovarian tube we find the germinal mass, together with the mediad wall of the ovary, projecting freely like a genital ridge, while opposite to it externally is a slight ridge of the wall of the body cavity continuous with the outer wall of the complete ovarian tube. The way in which the ovarian tube is formed is thus perfectly clear; the only question is whether the ridge which, by coalescing with the edge of the ovary, forms the tube is to be regarded as an independent projection from the wall of the body cavity, or as a portion of the genital ridge itself. The latter view is perhaps the most probable, and in that case the process in the sprat does not differ from that in *Belone* in kind, but only in degree; the size of the ovarian canal being very large in the sprat in comparison with the thickness of the walls.

What takes place then in the sprat is this. Along the dorsal wall of the body cavity external to the mesentery on

each side is a raised band covered by an epithelium, which is somewhat thick but not germinal. From the mediad side of this band projects a thick and deep fold, bearing on its outer side a germinal mass of young ova; from the external side of the band is a much smaller fold, which contains no young ova; the edges of these two folds coalesce, and thus the tubular ovary is formed.

In the posterior part of the body cavity, long before the point is reached where that cavity is divided into its two ultimate prolongations, all trace of the generative organs disappears. In tracing back the ovarian folds they are seen to become smaller and smaller, until they cease altogether. After the folds are no longer visible, the pair of slightly thickened bands in the wall of the body cavity can still be recognised, though they are not prominent, and farther back these also disappear altogether, and no further trace of ovary or oviduct can be seen. One peculiarity seen in a series of sections of the sprat deserves to be mentioned. The urinary vesicle does not extend forward in front of the point where the segmental ducts open into it, as is the case in most fishes; in the more anterior region of the body is seen a large tube between the kidneys and the body cavity; this is the large air-bladder, which passes backwards to *open to the exterior* behind the anus on the left side. In sections a little in front of the

after birth, and which were given to me by Prof. M'Intosh, no further development has taken place, except that the ova are more mature. The germinal epithelium extends round the whole inner surface of the tubular ovary, which ends blindly, both anteriorly and posteriorly. It will be necessary to examine stages both anterior to and subsequent to those I have had, in order to trace the development.

It will be seen, on comparing the description I have given of the development of the cavity of the ovary in the sprat with the figures and description given by Balfour and Parker concerning *Lepidosteus*,[1] that the mode of development is in the two cases exactly the same, except in one respect, namely, that peritoneal openings of segmental tubes were found within the ovarian cavity in *Lepidosteus*, while in the sprat I have not observed these. The specimen of *Lepidosteus* in which the formation of the front part of the ovarian tube was observed, was 11 cm. in length.

With regard to the male genital duct in *Lepidosteus* it was found that there existed in the adult a system of tubes placing the tubules of the testis in communication with the urinary tubes of the mesonephres, and so with the segmental duct, and no duct homologous to the female oviduct could be found. No observations seem yet to have been made on the development of this communicating system in the male *Lepidosteus*, which resembles what exists in *Elasmobranchs*. It is still uncertain what is the real nature of the genital ducts in other Ganoids. As for the male duct in Teleosteans, Brock[2] sees reason to believe that the *vas deferens* in them is of the same nature as the female oviduct, and not a Müllerian duct at all; but no embryological evidence on the question has yet been adduced.

More work is still urgently required on the development of the genital ducts in Teleosteans, Ganoids, and Dipnoans.

[1] Philosophical Transactions, 1882.

[2] "Geschlechtsorgane der Muraenidae," Mitt. Zool. Stat., Neupel 1881.

XXVI. *Notice of the capture of* Delphinus delphis *in the Firth of Forth.* By Professor Sir Wm. Turner, M.B., LL.D., F.R.S., President of the Society.

(Read 16th March 1887.)

In the month of February my assistant, Mr James Simpson, observed in the window of an Edinburgh fishmonger a specimen of a small cetacean—obviously not a porpoise. On inquiry he found that it had been shot in the Firth of Forth, and it was purchased for the Anatomical Museum of the University.

Mr J. Melville Webster of Cramond Manse has kindly communicated to me the following particulars of its capture. He was rowing, along with some companions, from Queensferry to Cramond, keeping close in shore, when, in a small bay on the Dalmeny estate between Queensferry and Hound Point, a school of six or eight small cetaceans, swimming about in pairs, was seen. Although Mr Webster could not say positively that they were all of the same species, as their beaks were not all seen above the water, yet it is probable that they were so. One animal was shot from the boat, but its companion, which escaped, was considerably bigger. In all probability the larger specimen was a male.

From the form and length of the beak, the number of

Teeth small, short, pointed, $\frac{41}{46}\frac{41}{46}$=174.

Colour.—The skin was black on the rostrum, the top of head, the back, both surfaces of the tail and dorsal fin. It was dark yellowish grey on both surfaces of the flipper. High up on the side of the body it was grey, with an undertint of fawn colour, then a lighter band about an inch wide commenced at the angle of the mouth, and extended horizontally backwards below the eye, but above the flipper, and widened out somewhat behind, when it ended on the side of the body in a broad, greyish white patch, a little in front of the tail. The side of the lower jaw had a yellowish grey tint similar to that of the side of the body, and this tint extended backwards below the lighter band just described as far as the broad, greyish white patch. The belly was white, and this tint was continued forwards to the under surface of the lower jaw, and backwards to behind the anus. The specimen showed that variety of tint and shading which has been described and figured by Professor Flower in his description of a common dolphin caught off the coast of Cornwall.[1]

The animal was distinguished by the elegance of its shape, which was in a great measure due to the mode in which it tapered both forwards to the beak and backwards to the tail. The lower jaw projected very slightly beyond the upper. The blowhole was single and crescentic, concave forwards, whilst its valve was convex backwards. The forehead descended gently to the beak, from which it was differentiated by a distinct V-shaped groove, the apex of which was forward at the base of the front of the forehead. The beak proper was attenuated; its length from the apex of the V-shaped groove to the tip was $4\frac{1}{4}$ inches. The skin of the beak was smooth when the animal was recently out of the water, but subsequently it became wrinkled. The anterior border of the dorsal fin was 2 feet 5 inches from the tip of the beak when measured along the curve of the back; the dorsal fin was falcate. The tail had a mesial notch $\frac{3}{4}$ inch deep. The vulva was immediately in front of the anus, and

[1] Trans. Zool. Soc., London, vol. xi., part i., 1880.

had a nipple slit on each side. The external auditory meatus was no bigger than a pinhole.

Although various specimens of the common dolphin have been captured on the English coast, and Mr Couch has stated that these animals come on the Cornish coast in considerable numbers, more especially when the pilchards and mackerel abound, yet there is a want of any definite information of its occurrence in the Scottish seas. Fleming and Jenyns in their systematic works on British animals, the author of the volume on whales in Jardine's Naturalists' Library, and Gray in his "Catalogue of Cetacea," are all silent on this matter. In the second edition of Bell's "British Quadrupeds," it is stated that the common dolphin appears to be much rarer on the shores of the more northern parts of Britain than in the south. Mr E. R. Alston, in his monograph on "The Fauna of Scotland," Glasgow, 1880, says, that though it probably occasionally visits the coasts of Scotland, as it does those of Norway, yet that he has been unable to find a single trustworthy account of its capture; and Mr Thomas Southwell, in his "Seals and Whales of the British Seas," London, 1881, remarks that there is no reliable record of its occurrence in Scottish waters.

The capture of this specimen in the Firth of Forth enables me now to make a definite statement on this matter, and to

XXVII. *Notes on* Chondrosteus acipenseroides, *Agassiz.* By Dr R. H. Traquair, F.R.S., F.G.S.

(Read 20th April 1887.)

The now well-known Liassic Acipenseroid fish *Chondrosteus acipenseroides* was named by Agassiz in 1843, but not described by him.[1] It subsequently formed the subject of an elaborate memoir by Sir Philip Grey-Egerton, Bart.,[2] in which, besides giving a minute account of the structure of the genus, he named two additional species—*C. pachyurus* and *C. crassior*. Putting the results of Sir Philip's investigations as briefly as possible, he maintained that while "in all essential points" *Chondrosteus* resembled the recent Sturgeon, nevertheless in certain others, and notably in the structure of the opercular and hyoid regions, it constituted a transitional form towards the more ordinary Ganoids. Moreover, the skin of the body presented the same naked condition seen in the recent *Polyodon*.

Eight years afterwards Professor Young read a paper on the subject before the Geological Society of London, of which only an abstract of six lines[3] is given in the Quarterly Journal. The object of the paper was to show that *Chondrosteus* was a Holostean, not a Chondrostean, because it "possesses a well-ossified basioccipital, and the lateral walls of the cranium are composed of bones answering to the cartilage bones of ordinary Teleostei."

In 1887 I placed the family "Chondrosteidæ" (including *Chondrosteus*) in the "Acipenseroid" suborder of Ganoids, between the Spatularidæ and the Palæoniscidæ, which latter family, along with the allied Platysomidæ, I proposed to include in one great group with the Sturgeons.[4]

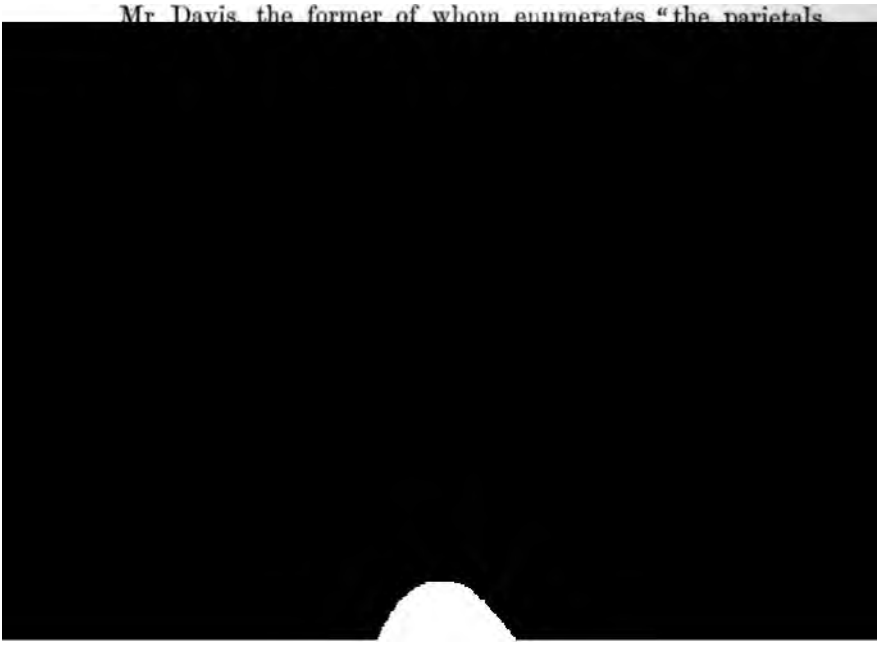
On the 9th March of the present year, Mr J. W. Davis read a paper on *Chondrosteus acipenseroides* before the Geolo-

[1] Poissons Fossiles, t. ii., pt. 2, p. 280.
[2] Phil. Trans., vol. 148 (1858), pp. 871-885.
[3] Quart. Journ. Geol. Soc., vol. xxii. (1866), p. 596.
[4] Ganoid Fishes of the British Carboniferous Formations, Pt. I. Palæoniscidæ, p. 42, Pal. Soc., 1877.

gical Society of London, of which an abstract has been published. In this paper Mr Davis interpreted the appearances presented by a single fine specimen in his own collection, and besides giving a detailed account of its anatomical structure, expressed his belief "that there is no specific difference between *C. acipenseroides*, Agassiz, and *C. crassior*, Egerton."

Mr Davis does not seem, however, to have made use of the magnificent suite of specimens of *Chondrosteus* in the British Museum, which contains not only the types of Sir Philip Egerton's figures, but also a splendid array of additional examples, mostly also from the Egerton and Enniskillen Collections. For the privilege of examining these, and of noting several new and interesting details presented by them, I am indebted to Dr Woodward, F.R.S., Keeper of the Geological Department; and my thanks are due also to Dr Geikie, F.R.S., and Mr E. T. Newton, F.G.S., for kindly permitting me to take notes of the specimens in the Museum of Practical Geology, Jermyn Street. In the present paper I propose to give an outline of the results derived from the study of the specimens in both Museums.

Cranial Shield.—The elements of the main portion of the cranial shield have been recognised by Sir P. Egerton and by Mr Davis, the former of whom enumerates "the parietals



is a rather small *posterior frontal* (*p.f.*). In no specimen which I have seen are the plates in advance of the frontals in sufficiently good preservation to enable one to map out or describe them: the outline of the snout as given in the restoration (Fig. 5) is therefore conjectural. Behind the

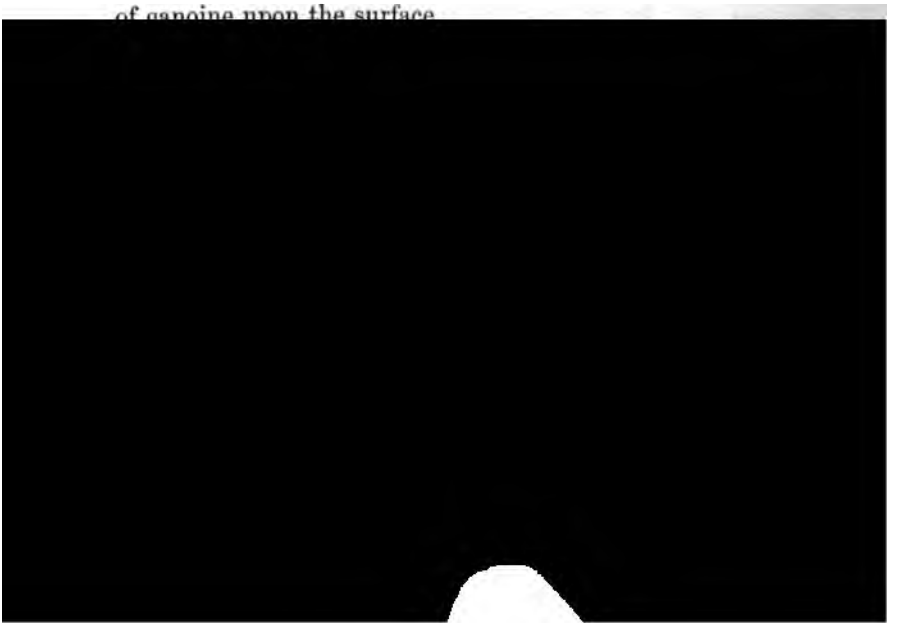
Fig. 1.—Cranial shield of a specimen of *Chondrosteus* in the Museum of Practical Geology, Jermyn Street. On the left side the displaced operculum (*op.*) is seen overlapping the post-temporal (*p.t.*) and outer supra-temporal (*s.t.*).

posterior margins of the parietals and squamosals, and between these and the post-temporal elements of the shoulder-girdle, is a transverse row of five small plates (*s.t.*). One of these, of a rudely polygonal shape, is median, and placed just at the union of the two parietals, and is flanked on each side

by another plate, of which the right is larger, the left smaller than itself. External to each of the latter is the remaining plate of each side, of considerably larger size, of an irregularly triangular shape, and placed between the posterior margin of the squamosal and the post-temporal (*p.t.*), which latter it largely overlaps. These are certainly the plates which in other Ganoid fishes (*Lepidosteus*, *Polypterus*) have sometimes been called "supra-occipitals" and "epiotics," but they are mere scale-bones, and occupy the place of the *supra-temporal* chain in Teleostei.

A very distinct *suborbital* bone (*s.o.*, Fig. 5) is seen in a large number of specimens. It consist of two limbs—an upper and longer vertical one meeting below at nearly a right angle with a shorter horizontal portion, the bone being considerably expanded at the junction. Above, the suborbital was suspended from the post-frontal region of the cranial shield,—below, it comes in contact with the middle of the maxilla. This suborbital is the bone which Sir Philip Egerton has interpreted as the "præmaxilla" in his memoir.

All these plates are externally marked with pores, and often with furrows and ridges radiating from the centres of ossification; often also the surface becomes corrugated, sometimes almost granulated; but I have seen no positive traces of ganoine upon the surface.



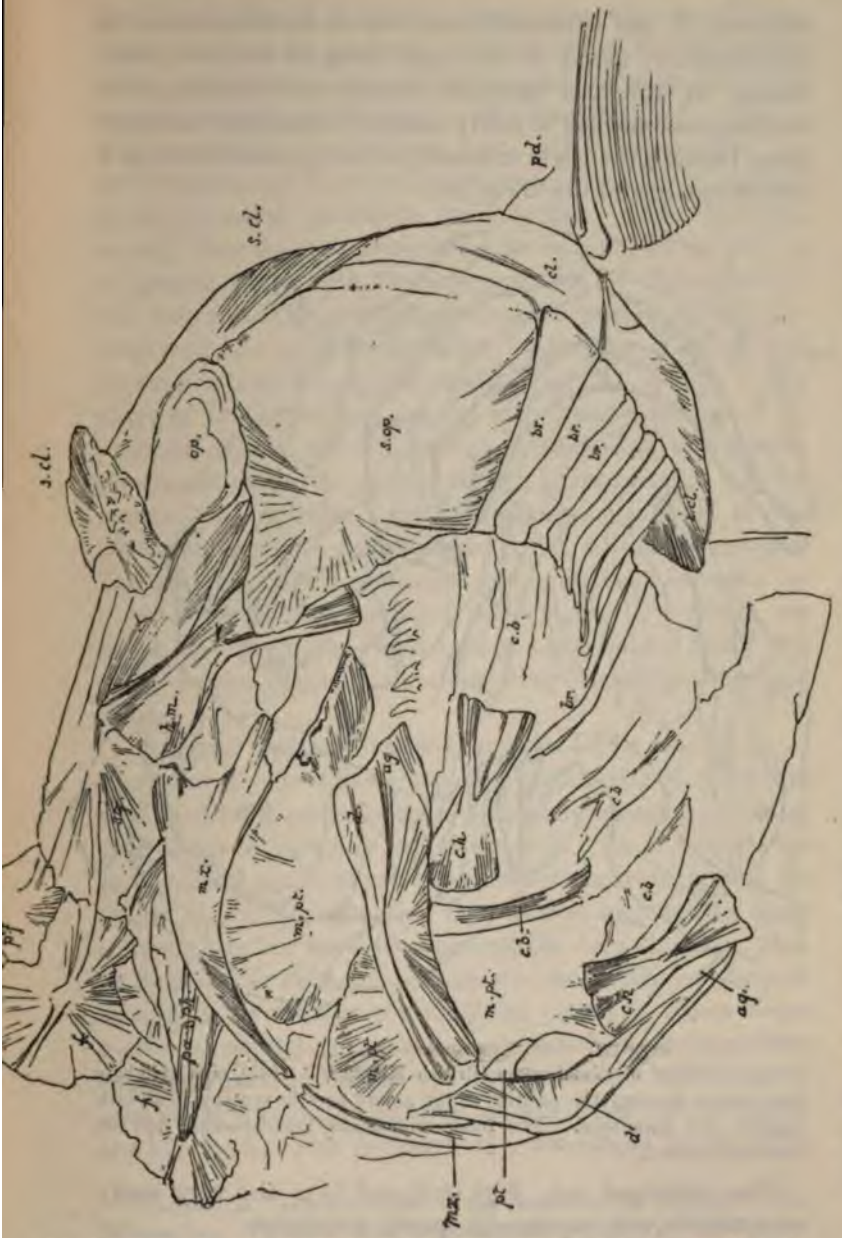


Fig. 2.—Head of *Chondrosteus* (British Museum, No. P. 2049). [Egerton Collection.] *See* explanatory note at foot.
In the lettering of this figure a mistake has occurred—the uppermost *s. cl.* should be *p. t.*

In this specimen the head is seen obliquely from below, and affords an excellent view of the shoulder-girdle, opercular apparatus, roof of the mouth, and inner surface of a portion of the cranial shield.

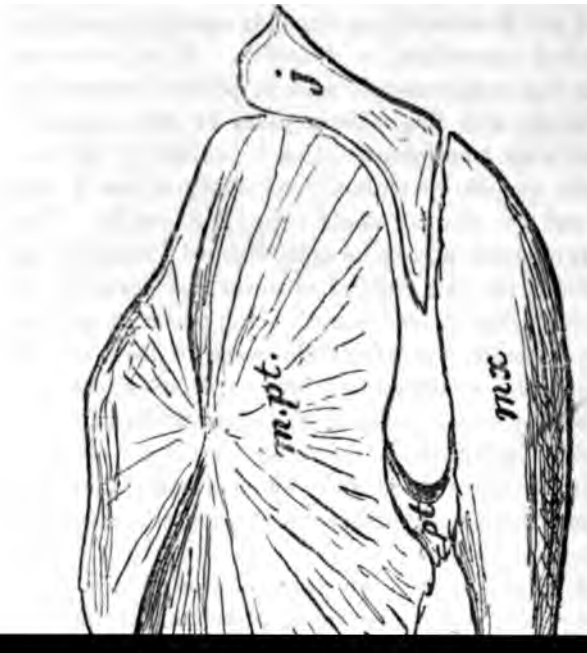
extremity of the hyomandibular towards the articulation of the mandible; this I do not insist upon, as it is not corroborated by any other specimen, though the existence of a cartilaginous one may be safely assumed, considering the large space between the lower extremity of the hyomandibular and the articulation of the lower jaw.

plate (*s.op.*, Figs. 2, 3, and 5), overlapping, with its anterior superior angle, the posterior inferior part of the hyomandibular, and leaving a considerable space between its upper concave margin and the edge of the cranial shield. This is the bone which has hitherto been called "operculum" in *Chondrosteus*, and it certainly corresponds exactly in position to the so-called operculum in *Polyodon*. It is, however, equally clear that it corresponds also in position, as well as in general shape, with the suboperculum of *Palæoniscus*;[1] and that this is its true interpretation is proved by the discovery of the proper operculum (*op.*) lying above it and between it and the cranial shield (Figs. 2, 3, and 5). The shape of this operculum may be aptly likened to that of an inverted comma, the tail passing upwards and forwards to the cranial shield, the convex margin being posterior and the concave one anterior, a considerable space in front of the bone and above the suboperculum being still left uncovered. The opercular flap is continued downwards and forwards by a series of ten imbricating *branchiostegals* (*br.*), which are broad and plate-like where they immediately follow the suboperculum, though anteriorly they become narrow and slender.

Jaws and palato-quadrate apparatus.—The maxilla (*mx.*) is a tolerably stout bone, tapering anteriorly and somewhat expanded in its posterior third—the posterior margin looking very obliquely upwards and backwards. As is well shown in Figures 2 and 3, it is curved inwards in front to meet its fellow of the opposite side in a perfect symphysis; there cannot, therefore, be a true præmaxilla here any more than in *Acipenser* or *Polyodon*. Articulated to the oblique posterior margin of the maxilla is a small flat plate (*j.*), whose shape somewhat reminds one of a boot, the sole being in apposition with the maxilla, while the leg is directed upwards and backwards towards the anterior margin of the suboperculum (*see* Fig. 4, *j.*). This is clearly the homologue of the little

[1] Described as "interoperculum" in my Memoir on the Structure of the Palæoniscidæ. I have, however, abandoned that view, and now consider the plate intercalated between it and the operculum in such genera as *Rhabdolepis* to be not a suboperculum, but merely an accessory element.

bone which in the recent Sturgeon is called "præoperculum" by Mr W. K. Parker,[1] although it seems to me and others to be the same "jugal" element which we find appended to the maxilla in *Amia*, *Salmo*, etc. In the Sturgeon it has also



s of left side of head of *Chondrosteus*, seen from above. Drawn from
n Coll., No. P. 3367, in the British Museum. *m.pt.* = mesopterygoid.
pt. = pterygoid, or ectopterygoid.

maxilla to *Chondrosteus*. But an examination of the original specimen represented in pl. lxix. of his memoir shows that his "præmaxilla" is the suborbital bone, and that his maxilla —the small bifurcate bone behind it—appertains to the palate, and will be described immediately as a pterygoid element! The real maxilla in this specimen is interpreted by Sir Philip as a mandible, while to this jugal plate he has assigned the name and position of *hypotympanic* (=quadrate).

Within the space bounded by the maxillæ, the roof of the mouth is principally composed of two plates (*m.pt.*, Figs. 2 and 4) of a somewhat oval or ovoid contour, narrower behind than in front. Anteriorly, these plates are placed behind the symphysis of the maxillæ; mesially, they articulate with each other along a portion of their internal margins, while externally each comes into contact with the maxilla of its own side for the anterior half of its length, behind which the margin recedes inwards, the little bone *pt.* being placed just where the recession takes place. These plates were recognised by Sir Philip Egerton as "palatine," and are undoubtedly the representatives of the two plates occupying a corresponding position in *Acipenser*, and which, although formerly usually reckoned as "palatines," are designated as "pterygoids" by Prof. W. K. Parker.[1] To my mind it seems to correspond more with the *mesopterygoid* of other fishes, and I have lettered it accordingly.

Placed at the middle of the outer edge of this last described bone, and articulating both with it and with the maxilla, is a small bone (*pt.*) which bifurcates posteriorly, one limb being placed along the maxilla, the other along the mesopterygoid palate-plate. This is the bone which Sir Philip Egerton has interpreted as "maxilla" (*op. cit.*, pl. lxix. 21), but whose true relations are most clearly seen in a large number of specimens in the British Museum. These relations are not obscure even in the specimen figured by Sir Philip; but here, as already explained, he unfortunately mistook the real maxilla for the lower jaw. As the position of this little bone is about the middle of the maxilla and *behind the suborbital*, we may feel a little surprised at the

[1] *Op. cit.*, p. 172.

following statement in the published abstract of Mr Davis's paper:—"From the position of the respective maxillary and premaxillary bones in this (Mr Davis's) specimen, there can be no further doubt that the small bifurcated bone of *C. acipenseroides*, Ag., described as the maxillary bone, is really the premaxillary" (!).

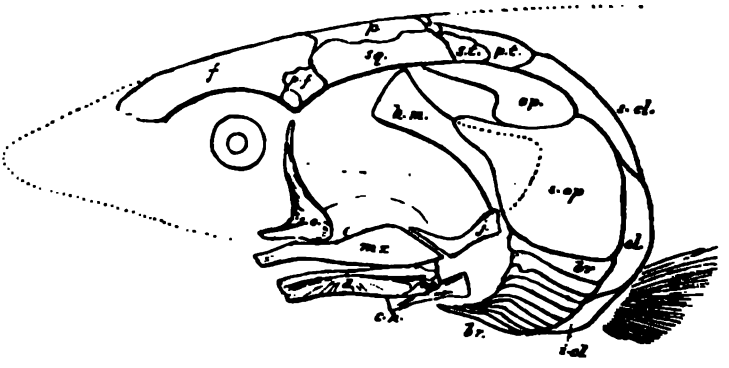
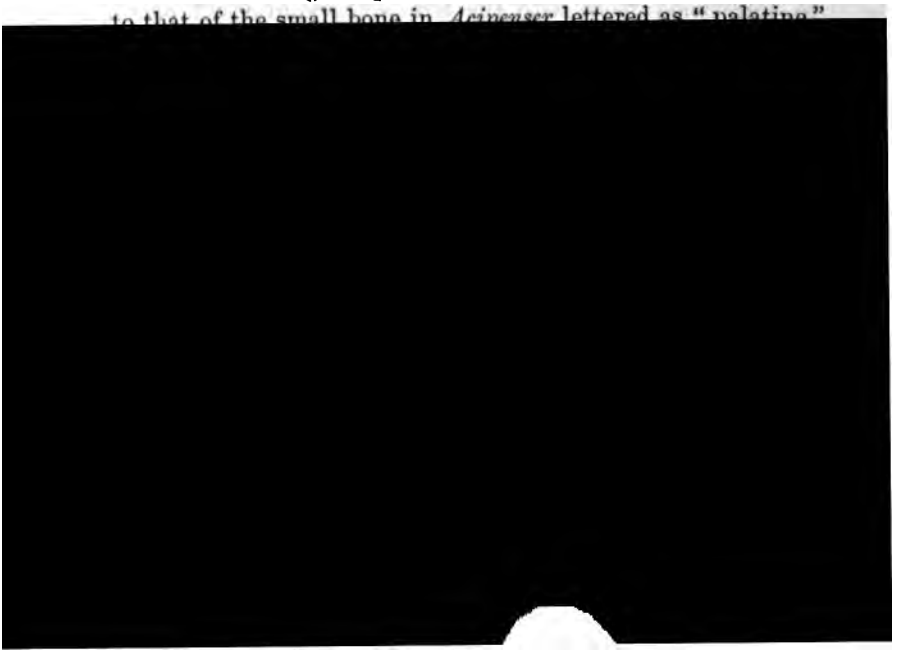


Fig. 5. Profile of head of *Chondrosteus*, restored.

But if we inquire what this little "bifurcated bone" really is, I answer that it seems to me to occupy, as regards the maxilla and the great palate-plate, a position quite analogous to that of the small bone in *Acipenser* lettered as "palatine"



margin about the middle of its extent, and then diverges downwards and backwards towards the angle. Sir Philip Egerton describes the mandible of each side as a single bone, and no doubt it is mostly composed of a large dentary element (*d.*, Fig. 3). But at its posterior extremity two other elements are undoubtedly present, of which one, the upper, may be reckoned as *articular*, while the other beneath it is unquestionably the *angular* (*ag.*).

No trace of teeth can be seen in connection with either jaw; *Chondrosteus* in this respect, as in so many others, resembling the recent *Acipenser*.

Branchial skeleton.—Abundant remains of ossified *ceratobranchials* (Fig. 2, *c.b.*) are seen in many of the specimens, but we need not be detained at present by entering into detail as to this part of the skeleton.

Shoulder-girdle.—Sir Philip Egerton states that whereas, in *Acipenser* three bones are present in the shoulder-girdle, viz., supra-scapular (post-temporal), scapular (supra-clavicular), and coracoid (clavicle), in *Chondrosteus* the "scapula" and "coracoid" have coalesced. In *Acipenser* there are, however, at least four membrane bones of the shoulder-girdle; the post-temporal being, however, immovably articulated with the cranial shield, while the fourth element is the large infra-clavicular plate. And Mr Davis, as regards *Chondrosteus*, is undoubtedly right in maintaining that the "scapula" and "coracoid" are not fused, though, as he enumerated only three elements in the shoulder-girdle, he seems not to have observed the infra-clavicular.

The *post-temporal* (Figs. 1 and 2, *p.t.*) is a somewhat three-cornered plate placed behind the posterior margin of the cranial shield, and having its anterior margin overlapped by the supra-temporal bones. This is followed by the *supra-clavicular* (Fig. 2, *s.cl.*), an oblong bone passing obliquely downwards and backwards, and having its upper extremity obliquely perforated by the side-canal. Its distinctness from the clavicle is obvious in every well-preserved specimen. This clavicle (Figs. 2 and 3, *cl.*) differs from that of the Sturgeon in not being so much developed inferiorly, so that the next element, the *infra-clavicular* (*i.cl.*), articulates to its

lower margin, extends higher up, and comes to be opposite a considerable portion of the origin of the pectoral fin. There is still another plate (Fig. 3, *p.cl.*), though it is a very small one, appended to the posterior margin of the clavicle, and this we may recognise as corresponding to the *post-clavicula* of *Polyodon* and the Palæoniscidæ.

I have seen no evidence of ossification in the scapulo-coracoid cartilage, nor does any specimen afford a view of the base of the pectoral fin, though in some a few dislocated radials may be seen in this position. It is probable that the arrangements here resembled those in *Acipenser*, and I own I am somewhat at a loss to understand the "two bones" to which Mr Davis alludes as "apparently representing the radius and ulna of Owen (coracoid and scapula of Parker)."

The limits of the present paper hardly permit my entering into detail as to the rest of the structure of *Chondrosteus*. So far as the internal skeleton is concerned, its remains indicate a structure very similar to that in *Acipenser*, while the fins in shape and arrangement much resemble those of *Polyodon*.

Conclusion.—Although there is no evidence of any long snout, *Chondrosteus* resembled *Polyodon* in the general shape of the body, in the form and arrangement of the fins, and above all in the absence of *scales* on any part save the pre-

chain, and where the post-temporal is movably articulated, —whereas in *Acipenser* the frontals are entirely separated by an intercalated plate, and the post-temporals and two of the median body-plates are immovably joined to, and form a part of the cranial buckler itself. Especially palæoniscoid is, however, the aspect of the opercular and branchiostegal apparatus, as will be seen if the reader will compare the restored drawing (Fig. 5) with the figures of the heads of *Palæoniscus* and *Nematoptychius* given in my account of the Palæoniscidæ, although in *Chondrosteus* there is no præoperculum and the series of branchiostegal rays of the two sides may not have met in the middle. The special resemblance of the shoulder-girdle to that of *Palæoniscus* is also very striking, especially in the form of the post-temporal and supra-clavicular bones.

In my already quoted essay on the structure of the Palæoniscidæ, I pointed out certain strange and previously unrecognised resemblances which *Palæoniscus* bore to *Polyodon*, especially in the internal skeleton, the shoulder-girdle, and the jaws and palato-quadrate apparatus (even although there *are* premaxillary bones and there is no evidence that the palato-quadrate elements met in the middle line in front). I also remarked that the resemblances between *Palæoniscus* and *Acipenser* are of course much less prominent. Here, however, is a form which in many of its features presents strong Palæoniscoid resemblances, but whose affinities are, nevertheless, more with *Acipenser* than with *Polyodon!*

The affinities of *Chondrosteus* seem, therefore, to radiate in three directions, towards *Acipenser*, towards *Polyodon*, and towards the Palæoniscidæ, and certainly, of all the three directions, the distance towards *Acipenser* is the least.

XXVIII. *Notes on the British Species of* Zeugopterus. By George Brook, Esq., F.L.S., Lecturer on Comparative Embryology in the University of Edinburgh. [Plates XIV.-XVI.]

(Read 15th December 1886.)

In the year 1835, Gottsche (1) proposed to divide the species hitherto included in Klein's genus Rhombus into three sections, retaining the name *Rhombus* for that section including the turbot and brill. His divisions were as follow:

1. Ventrals free from anal; scales none, or small and cycloid, ... Rhombus.
2. Ventrals free from anal; scales small and ciliated, ... Lepidorhombus.
3. Ventrals united with anal, . . . Zeugopterus.

The generic name *Lepidorhombus* has not been adopted by subsequent authors, with the exception of Günther (2), while the name *Zeugopterus* has been utilised by various authorities in a different sense or discarded altogether. Yarrell (3), Couch (4), Nilsson (5), and Collett (6), and some other observers, appear to agree in practically uniting the two genera *Lepidorhombus* and *Zeugopterus* of Gottsche into one genus.

and *punctatus*—under the genus *Zeugopterus*, *R. unimaculatus* not being met with in Norwegian waters. This species, however, is found in the Mediterranean, and has been included in the genus *Zeugopterus* by Giglioli (**8**). It will thus be seen that the genus *Zeugopterus* is made to include species in which the ventrals are free from the anal, and also one (*Z. punctatus*) having the ventrals united with the anal. The condition of the ventral fins ceases therefore to be of generic value.

Recently Day (**9**) has rearranged the British species as follows: The *R. megastoma* of Donovan is included in Bleeker's genus ARNOGLOSSUS, along with the mergrim, *A. laterna*. *R. norvegicus*, a species which has not yet been found in British waters, would also probably be included in this genus. The remaining species—viz., *R. punctatus* and *R. unimaculatus*—form the genus *Zeugopterus* as understood by Day. Thus the second and third divisions of the genus RHOMBUS, as defined by Gottsche, have been broken down, and the genus ZEUGOPTERUS, as recently defined, includes species in which the ventrals may or may not be united to the anals, the generic characters depending on other features. The following are the characters defined by Day: "Branchiostegals, seven; pseudobranchiæ present; eyes on the left side, and close together; cleft of mouth deep; sharp villiform teeth in a band in either jaw, present or absent from the vomer. The dorsal fin commences before the upper eye; its rays and those of the anal are nearly all branched; caudal not united to the vertical fins; the ventrals either free from or united to the anal; scales ctenoid; lateral line having a strong curve anteriorly."

The majority of these characters are not confined to the genus *Zeugopterus*, but are also common to the genera *Rhombus* and *Arnoglossus*.

An examination of the British species of *Pleuronectidæ* will show that the genera fall more or less naturally into three groups, *Rhombus* and its allies occupying an intermediate position between *Hippoglossus* and *Pleuronectes*. In order to grasp more surely the relation of *Zeugopterus* to the other *Pleuronectidæ*, I subjoin a table, showing this

grouping, based on those characters which appear common to each group, those of generic value being omitted:

PLEURONECTIDÆ

A. Jaws and dentition about equally developed on both sides; cleft of mouth, deep.

(1.) Eyes on right side, { *Hippoglossus.* *Hippoglossoides.*

(2.) Eyes on left side, { *Rhombus.* *Zeugopterus.* *Arnoglossus.*

B. Jaws and dentition more developed on the blind side; eyes on the right side; cleft of mouth, shallow.

Pleuronectes.
Solea.

The three genera with the eyes on the left side include, in the main, the species comprised in Klein's genus *Rhombus*, as originally constituted. All possess the following, amongst other characters, not including characters common to the *Pleuronectidæ* generally: Branchiostegals, usually seven; eyes on the left side; teeth in a band, usually villiform, none on the palatines; dorsal fin commences considerably in front of the eyes; most of its rays, and those of the anal, branched (except in *A. laterna*).

The continuation of the dorsal fin on to the snout, and the situation of the eyes on the left side, are points which in

Distribution.—Shores of Northern Europe to the Mediterranean.

A feature common to all the species of the genus *Zeugopterus*, as here understood, is the constant occurrence of a flap-like accessory portion of the vertical fins situated under the tail. In a former paper (**10**) I described the use of this peculiar modification of the vertical fins in aiding respiration. From further observation of its action, I am inclined to think too much stress was then laid on the action of the accessory flap. Under normal circumstances, when a specimen of *Zeugopterus* adheres closely to a smooth surface by a backward pressure of the rays of the dorsal and anal, the body is arched, and a space is left between the under side of the fish and the surface to which it adheres. Through this channel a constant current of water is made to pass from the branchial chamber on the under side to the tail. The basal portions of the vertical fins are kept in constant motion during this time, but the motion is more vigorous in the rays immediately *in front of the tail* than in the accessory flaps situated underneath it.

In *Z. punctatus* and *Z. papillosus* the ventrals are united with the anal, the anal papilla being situated between the two ventrals. In *Z. unimaculatus*, on the contrary, the ventrals are free. The anal papilla is, however, situated between the two ventrals as in the other species, and the rays of the anal fin near its anterior extremity become shorter and shorter, and the fin gradually tapers away to the anal papilla. The ventral fins, therefore, cover the anterior extremity of the anal on both sides, and thus *appear* to be continuous with it in a living specimen. It is only when the ventrals are pulled to one side that they are found to be unattached to the anal. The position of the anal papilla *between the ventrals*, and not behind them as in other *Pleuronectidæ*, appears to be of generic value.

The ciliated cycloid scales are also characteristic, and give the species of this genus an appearance peculiar to themselves amongst British Pleuronectidæ at least. Figures of these scales will be found on Plates XIV.-XVI.

In all three species the scales have a number of spinous processes on their free margins, but the comparative strength of these is not sufficiently constant to be of specific value. Nevertheless, in each species there is a tendency for a particular form of scale to predominate. In all three species the central spine is strongly developed. In *Z. unimaculatus* there are three central spines much stronger than the others, but of these the two lateral ones are usually slightly shorter than that between them. In *Z. punctatus* the central spine is very strong, and the lateral ones, none of which approach it in size, become smaller and smaller towards the lateral margin. In *Z. papillosus* the arrangement is similar to that in *Z. punctatus*, but all the lateral spines are so much reduced as to exaggerate the importance of the central one. Such is the *typical* scale structure of the species here described, but it is easily possible to find intermediate forms, which link the extremes together.

1. Z. PUNCTATUS, Bloch. (Pl. XIV.)

Pleuronectes punctatus, Bl.
,, *hirtus*, Ahlg.
Zeugopterus punctatus, Day.

Fin formula (Day).—D, 87-101; A, 69-80; P, 10; V, 6; C, 14-16.
Fin formula (own specimens).— D, 97-102; A, 78, 79; P, *upper*, $\frac{1}{1}$;

Scales on the left side strongly spinous, those on the right smooth or nearly so; scales only imperfectly developed on the under side of the dorsal and anal; filaments or papillæ not evident on the coloured side.

Distribution.—From the shores of Norway to the northern shores of France.

This species appears to be of frequent occurrence on the East Coast of Great Britain and in the English Channel. It also extends to the West Coast and the eastern shores of Ireland. I have not met with it in the Clyde estuary, but Mr Anderson Smith has recorded its occurrence in Loch Creran.

My largest specimen measures 8¼ inches in length, and several others have come into my hands measuring over 7 inches.

2. Z. PAPILLOSUS, n. sp. (Pl. XV.)

Fin formula.—D, 94, 95; A, 68, 69; P, 12.; V, 6; C, 16.

The dorsal fin commences at the anterior margin of the maxillæ; none of the rays are produced into fleshy filaments. The accessory portions of the dorsal and anal appear to consist of three much branched rays. The inter-orbital septum is very narrow, and is not raised, the eyes nearly touching one another. The left eye is not so much in advance of the right as in the other two species, but young specimens of *Z. unimaculatus* have the eyes placed nearly vertically one above the other, while in some of the larger ones the left eye is half its diameter in front of the right. This character may, therefore, be of little specific value. The anterior dorsal margin of the body is more arched than the ventral, so that a continuation of the posterior straight portion of the lateral line would pass *above* the inter-orbital ridge.

The left pectoral is considerably longer than the right; each usually contains twelve rays, but the first ray in the left is shorter than the others.

Scales on the left side spinous, those on the right smooth and small. The scales apparently do not extend to the vertical fins on the *right* side. The skin on the coloured side is densely papillose, this feature being particularly well marked on the head and anterior portion of the trunk.

In colour this species is very striking. The ground colour is a bright yellowish brown, with dark brown spots and patches. A dark spot or patch extends backward obliquely from each eye. There is a round dark spot about the middle of the straight part of the lateral line, and another at the commencement of the curved portion, while there are several smaller ones on the posterior part of the head, and one at the base of the pectoral. The vertical fins are pale, but every sixth or seventh ray is dark, the deeper colour being continued some distance on to the body, and ending in a rounded dilation.

In number of rays in the dorsal and anal fins, this species is intermediate between *Z. punctatus* and *Z. unimaculatus*, as will be seen from the following table:

Species.	Dorsal.	Anal.
Z. punctatus, ...	97-102	78-79
Z. papillosus, ...	94-95	68-69
Z. unimaculatus, . . .	75-85	61-67
	(Average 80).	(Average 64).

Distribution.—As yet I have only met with this form in the Clyde estuary. It frequents shallow water, particularly sandy bays overgrown with Zostera. I have taken it, in company with *Z. unimaculatus*, in Loch Striven and in Rothesay Bay; and Mr Thomas Scott has also taken one or

branched. The accessory portion of the dorsal and anal usually consists of four branched rays. The inter-orbital septum is raised, forming a sharp ridge along the dorsal margin of the left orbit, but is only very slightly raised on the upper side, its diameter being about a quarter that of the eye.

A continuation of the posterior straight portion of the lateral line would pass through the inter-orbital ridge. The left pectoral extends a little beyond the curved portion of the lateral line; the right is a little shorter, but the difference in size is not so great as in *Z. punctatus*. The first ray is slightly stronger than the others, and is unbranched, but is not so long as those immediately succeeding it.

The left pectoral frequently has ten rays, and the right only nine.

Scales on the left side strongly spinous, those on the right being ciliated. Scales prominent on the under side of the dorsal and anal. The skin on the coloured side bears numerous filaments, which are irregularly distributed and frequently pigmented.

Distribution.—From the shores of Denmark, around the British Isles, to the Mediterranean.

This species does not appear to be recorded from the coast of Norway. I have not met with it amongst specimens examined from the east coast of Scotland, but on the west it appears abundant in suitable localities. I have taken three with one haul of the trawl in Loch Fyne. I have also met with this species in the Kyles of Bute, on the shores of Mull, and in the Gair Loch, Ross-shire. My specimens vary from three to six inches in length.

List of References to Literature.

1. **Gottsche.**—Wiegm. Arch., 1835.
2. **Günther.**—Cat. Fishes Brit. Mus., vol. iv.
3. **Yarrell.**—British Fishes, ed. iii.
4. **Couch.**—British Fishes.
5. **Nilsson.**—Skan. Fauna (Fisk).
6. **Collett.**—Norges Fiske.
7. **Steenstrup.**—Overs. Dansk. Vid. Setsk, 1865.
8. **Giglioli.**—Cat. Pesc. Ital.
9. **Day.**—British Fishes, part iv., 1882.
10. **Brook.**—Fourth Ann. Rep. Fish. Board, Scotland, 1886.

XXIX. *Notes on the Reproduction of Lost Parts in the Lobster* (Homarus vulgaris). By GEORGE BROOK, Esq., F.L.S., Lecturer on Comparative Embryology in the University of Edinburgh. [Plate XVII.]

(Read 17th March 1886.)

Over a century and a half ago, Réaumur (1 and 2) published an elaborate account of the process of ecdysis in Crustacea, and of the manner in which lost or injured limbs are replaced by new ones. His investigations on the reproduction of lost parts were so complete, that little has been added to them up to the present time. It was Réaumur who first discovered that in the Decapods the injured limbs are usually reproduced from the basal joint. He showed that if a pincer claw is broken at the first, second, or third joint, the mutilated limb is generally cast off at the *fourth* joint within a few days, and the new limb develops from this point. He adds, however: "Quoiqu'il en soit de la raison pour laquelle les jambes se trouvent communément cassées dans la suture qui est proche de la quatrième articulation, j'ai vû diverses fois naître des parties de jambes qui n'avoient

The limb is then ready to be set free, and the membrane bursts. The new limb when liberated is about half the size of the one lost. This process takes from three to six weeks according to circumstances. With each successive moult the new limb increases considerably in size, so that in time it becomes similar in size to its fellow. According to Réaumur, the ambulatory limbs are produced in a similar manner, but more slowly. "D'ailleurs étant moins exposées à se casser, parcequ'elles ne sont pas terminées par de grosses pinces, elles se reproduisent et plus rarement, et ce qui est toujours à remarquer plus lentement."

J. Couch, in a paper "On the process of Exuviation and Growth of Crabs and Lobsters" (**3**), gives some notes on the reproduction of lost limbs, which, however, are chiefly a *résumé* of Réaumur's researches.

The next important contribution to the subject was made by H. D. S. Goodsir, in a paper read before the Wernerian Society in December 1843 (**4**). Goodsir suggested a reason why the lost limbs are usually reproduced from the first phalanx. He says: "A small glandular-like body exists at this spot in each of the limbs, which supplies the germs for future legs. This body completely fills up the cavity of the shell for the extent of about half an inch in length. The microscopic structure of this glandular-like body is very peculiar, consisting of a great number of large nucleated cells, which are interspersed throughout a fibro-gelatinous mass. A single branch of each of the great vessels, accompanied by a branch of nerve, runs through a small foramen near the centre of this body, but there is no vestige either of muscle or tendon, the attachment of which are at each extremity. In fact, this body is perfectly defined, and can be turned out of the shell without being much injured. When the limb is thrown off the blood-vessels and nerve retract, thus leaving a small cavity in the new-made surface. It is from this cavity that the germ of the future leg springs, and it is first seen as a nucleated cell."

In 1873, Chantran (**5**) published a series of observations on the Crayfish, giving the time required for the reproduction of lost parts in that species. He says that lost antennæ are

... between the moult and
... les grosses pattes.
... de la queue, se
... avant lieu durant leur
... mue les membres
... It appears also from his
... only once a year,
... in the same time.
... the male attain their full
... two years, while in the
... over three or four

... 7 gives a *resume*
... as that form is con-
... summary of Réaumur's
... point of difference which
... the formation of the
... its thin cuticle, Huxley
... cuticle is thrown
... skeleton; while the rudi-
... though very small, acquires
... limb."

... with the process of
... studied by Max Braun (6) and

The following extracts from my diary will show the observations made:

LOBSTER A.

5, iii. 83.—In removing this specimen to another tank it threw off both chelate claws by the basal joint, and also the flagellum of the left antenna.

8, iii. 83.—The scars on the basal joints of chelate limbs and left antenna have become covered with a thin white pellicle.

13, iv. 83.—No signs of reproduction of lost appendages.

11, v. 83.—There is now a pallid white process arising, like a spine, from the middle of the scar of each limb. Length a little under $\frac{1}{8}$ in.

16, v. 83.—Length of process for chelæ nearly $\frac{5}{16}$ in., and the joints of the future limb are marked out by faint constrictions beneath the pellicle, and the pincers by a faint groove on each side. The two grooves meet at the apex, forming a notch (*cf.* fig. 3). The basal portion of process is wider than on previous date.

Left antenna has a pallid white process, similar to that forming the rudiment of chelæ on previous date. Length rather less than $\frac{1}{8}$ in., widened at base. Process is as yet quite straight and spine-like.

21, v. 83.—Two apical joints of chelæ are now bent inwards. No colour changes observable.

29, v. 83.—Length of chelate rudiments, $\frac{5}{16}$ in. Left antenna has now become twisted at the apex, forming a half-spiral turn (*see* fig. 1).

12, vi. 83.—Length of chelate rudiments, $\frac{7}{16}$ in. Twisted portion of antenna forms about one complete coil.

26, vi. 83.—Length of chelate rudiments, $\frac{9}{16}$ in. These rudiments have now assumed a flesh tint. Coil of antenna close, measures $\frac{3}{32}$ in. A faint red tint is becoming marked in this rudiment also.

3, vii. 83.—Length of chelate rudiments, $\frac{11}{16}$ in. Red tinge very pronounced, excepting at base and tip. The colour is now blood red. Coiled portion of antenna now measures $\frac{5}{32}$ in. Colour not so dark as chelæ.

17, vii. 83.—Length of chelæ, $\frac{13}{16}$ in. Blue suffusions are making their appearance amongst the red.

1, viii. 83.—Length of chelæ, $1\frac{1}{4}$ in. Length of coiled portion of antenna, $\frac{5}{16}$ in.

22, viii. 83.—Length of chelæ, $1\frac{3}{16}$ in. During the last few days these rudiments have assumed the same dark tints (even darker) as the other uninjured limbs, due to the same suffusions of dark blue. Coiled portion of left antenna $\frac{7}{32}$ in. Colour brilliant flesh red, paler at the tip.

25, viii. 83.—Ecdysis had taken place during the night. The thin mem-

brane enclosing the new chelate limbs remained unburst (?), and was cast off with the exo-skeleton during ecdysis, remaining attached to the basal joint in each case. After ecdysis the new limbs increased rapidly in size, and had assumed considerable proportions before the new shell became hardened, a process which usually occupies several days. Owing to liability to irregularity in measurements of the total length of chelate limbs, I have taken the relative size of the terminal (pincer) joint as a safer guide in comparisons. The length of the pincer joint in the limbs thrown off 5, iii. 83 was, for that of the right limb, 3½ in.; and of the left, $3\frac{9}{16}$ in. When the new skeleton became thoroughly hardened, the corresponding joints of the new limbs measured respectively, 2¼ and 2⅛ in.

The new antenna on this date had attained a length of 5 or 6 in., but unfortunately it received an injury, and the terminal portion broke away, so that I am unable to give precise measurements.

This specimen died 1, i. 84, before any further ecdysis had taken place.

Lobster B.

Had lost during the winter (no precise date kept) the right chela, the fifth leg on the right side, and the fourth on the left side.

13, iv. 83.—Rudiment of pincer claw about 1 in. long, and extends a little beyond the middle of the third joint (ischiopodite) of the third pair of limbs. Rudiments of the lost ambulatory limbs reach to about the middle of the fourth joint (meropodite) of the preceding leg. The new limbs are pallid white, tinted with flesh colour, and have the full complement of joints. These are, however, quite rigid.

11, v. 83.—Process of chela 1⅞ in. long; other legs 1 in. long. The new

uninjured fellows, so that it was impossible to distinguish between them.

20, ix. 83.—Has again gone through ecdysis during the past night, and has partially buried its cast shell. The right chela now approaches the left in size, and indeed there is no greater difference between them than is usually found (*see* general table for measurements). The left antenna has now developed a flagellum from a spiral rudiment, formed since last ecdysis. It is, however, still shorter than the right. There is an absence of the brown red colour in this specimen after ecdysis, excepting as an occasional faint stain on some of the joints of the ambulatory limbs and at the apex of the left chela. The colour of the animal is almost a uniform dull prussian blue. The parts (such as the tubercles of the chelæ, etc.), which become ultimately more or less red, are now pallid white, with a trace of blue. The antennæ are also abnormal in colour, being of a fulvous shade. The antennæ still retained this fulvous shade so long as the specimen was kept under observation (28, i. 85).

13, v. 84.—This specimen passed through another ecdysis during the night. The difference in length between the right and left pincer joints has now been reduced to $\frac{1}{4}$ in.

13, x. 84.—Another ecdysis during the past night, and the specimen has buried its exuvium. The whole animal (9 A.M.) is of a uniform dull prussian blue colour, as previously described, and without any trace of the red brown usually found after ecdysis. The antennæ are fulvous. The whole animal has increased in size, but there is still $\frac{1}{4}$ in. difference between the length of the right and left pincer joints. The left antenna has increased 3 in. in length with the present ecdysis, and is now only $2\frac{3}{8}$ in. shorter than the right.

Lobster C.

7, xii. 82.—Lost smaller chela (left) in a struggle with another lobster. Has also lost both antennæ.

6, ii. 83.—Lost right chela during the past night.

13, iv. 83.—Rudiment of left chela about $\frac{1}{2}$ in. long; that of right, $\frac{1}{4}$ in. Both are pallid white, with washes of flesh colour. Have full complement of joints, which, however, are still rigid. No trace of rudiment of right antenna. That of left forms a short hooked process, as described for Lobster **A**.

11, v. 83.—Length of left chelate rudiment, $\frac{1}{4}\frac{3}{2}$ in.; right, $\frac{7}{16}$ in. The left is strongly tinged with pink on the pincer joint, and stained with blue on the basal joints. The rudimentary left antenna forms a pallid white process, the apex of which is spirally twisted in a close coil. The twisted portion forms an obtuse angle with the base, which is somewhat conical.

29, v. 83.—Length of left chelate rudiment, 1 in.; right, $\frac{3}{4}$ in. Latter is

now stained with blue. Left antenna has developed more coils, and has assumed a pink tinge. Length of coiled portion, $\frac{1}{8}$ in.

5, vi. 83.—Left chela, barely $1\frac{1}{8}$ in. long; right, $1\frac{2}{8}$ in.

12, vi. 83.—Left chela, $1\frac{1}{4}$ in. long; right, $1\frac{3}{16}$ in.

19, vi. 83.—Left chela, just over $1\frac{1}{4}$ in. long; right, $1\frac{5}{16}$ in.

26, vi. 83.—Left chela, $1\frac{5}{16}$ long; right, $1\frac{1}{4}$ in. Coiled portion of left antenna is now slightly over $\frac{1}{4}$ in. long, and the colour is bright brownish red, paler at the apex. The base is flesh coloured, with blue stains. The amount of blue pigment in the new chelate limbs has rapidly increased, so that now they are as dark as their uninjured fellows.

1, vii. 83.—Ecdysis has taken place during the past night. (For measurements of new appendages, *see* table.)

14, viii. 83.—This specimen has again lost both chelæ in a fight with Lobster **B**.

5, x. 83.—Rudiments of both chelate limbs have again made their appearance. The rudimentary antenna has its apex arranged in a spiral of four diminishing coils.

[Again the rudiment of the right chela was a little smaller than that of the left. During November and the early part of December this difference became less and less marked until 16, xii. 83, when both measured about $1\frac{1}{8}$ in. in length. I have a series of eight intermediate measurements, but as these are very similar to those taken prior to the last ecdysis, it will not be necessary to give them here. At no time was the difference in size so marked as on the previous occasion, a fact which is probably due to the two chelæ having been lost at the

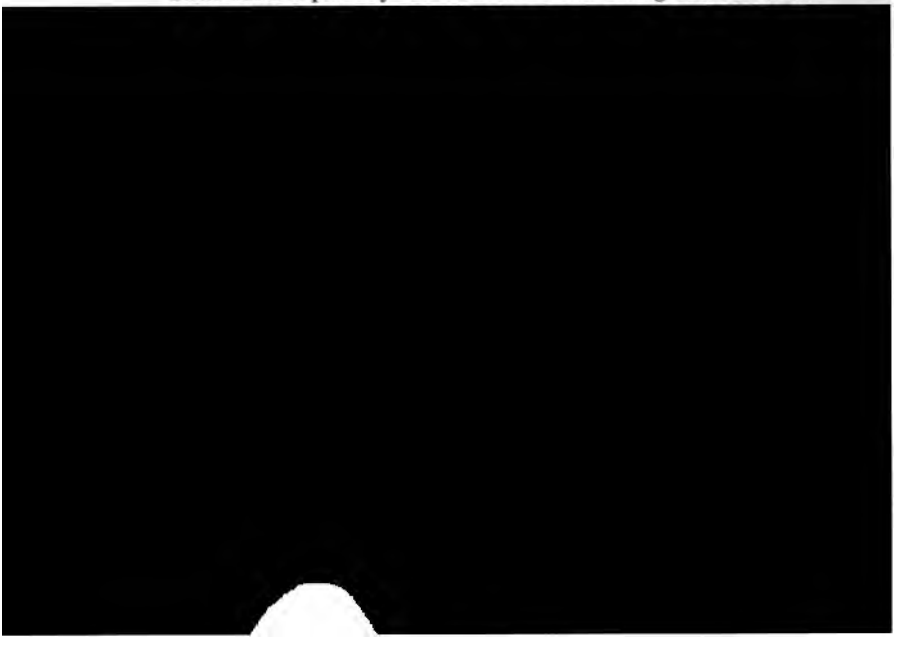


TABLE OF MEASUREMENTS—LENGTH IN INCHES.

	Carapace.	Abdomen.	Total Length.	Right Pincer Joint.	Left Pincer Joint.	Antennæ. Right Flagellum.	Antennæ. Left Flagellum.
LOBSTER **A.** before ecdysis, . . .	$3\frac{11}{16}$	$4\frac{7}{8}$	$8\frac{9}{16}$	$3\frac{1}{2}$	$3\frac{9}{16}$	...	...
after ,, . . .	$3\frac{7}{8}$	$5\frac{1}{8}$	9	$2\frac{1}{4}$	$2\frac{1}{2}$	...	...
LOBSTER **B.** previous to ecdysis, 19, v. 83,	$3\frac{3}{16}$	4	$7\frac{3}{16}$	...	3	...	broken
after ,, 19, v. 83,	$3\frac{7}{16}$	$4\frac{1}{2}$	$7\frac{15}{16}$	$2\frac{3}{8}$	$3\frac{3}{32}$	$3\frac{11}{16}$	...
,, ,, 20, ix. 83,	$3\frac{7}{8}$	$5\frac{1}{16}$	$8\frac{13}{16}$	$3\frac{3}{8}$	$3\frac{7}{16}$	6	$4\frac{3}{8}$
,, ,, 13, v. 83,	$4\frac{1}{8}$	$5\frac{1}{4}$	$9\frac{3}{32}$	$3\frac{7}{8}$	$4\frac{1}{8}$	8	$4\frac{1}{2}$
,, ,, 13, x. 83,	$4\frac{1}{2}$	$5\frac{1}{4}$	$9\frac{3}{4}$	$4\frac{1}{4}$	$4\frac{1}{2}$	$9\frac{7}{8}$	$7\frac{1}{2}$
LOBSTER **C.** previous to ecdysis, 1, vii. 83,	$2\frac{7}{8}$	$4\frac{1}{16}$	$6\frac{15}{16}$	...	...	...	...
after ,, 1, vii. 83,	3	$4\frac{3}{16}$	$7\frac{3}{16}$	$2\frac{3}{16}$	$2\frac{1}{16}$	...	2
,, ,, 25, xii. 83,	$3\frac{5}{8}$	$4\frac{11}{16}$	8	3	...	...	$3\frac{3}{4}$
,, ,, 25, vi. 84,	$3\frac{5}{8}$	$5\frac{1}{4}$	$8\frac{7}{8}$	$2\frac{7}{8}$	$2\frac{13}{16}$	$3\frac{9}{16}$	$5\frac{7}{8}$
,, ,, 19, xi. 84,	$3\frac{7}{8}$	$5\frac{1}{2}$	$9\frac{3}{8}$	$3\frac{7}{16}$	$3\frac{9}{16}$	$5\frac{9}{16}$	$7\frac{9}{16}$
LOBSTER **D.** Given as instance of normal growth, no appendages having been lost.							
Before ecdysis, . . .	$4\frac{3}{32}$	$5\frac{3}{4}$	$10\frac{1}{8}$	$4\frac{3}{32}$	$4\frac{9}{16}$	not noted.	
After ,, . . .	$4\frac{9}{16}$	$6\frac{9}{32}$	$11\frac{1}{8}$	$4\frac{3}{4}$	5	,,	

NOTE.—The preceding measurements are all taken from the preserved exuvia, or from the living lobster.

Length of carapace is taken from tip of rostrum to posterior edge of carapace.

Length of abdomen is taken from posterior edge of carapace to apex of telson (excluding fringe). This measurement is not so exact as that of carapace, since a variation in the amount of overlapping of the abdominal somites in drying will affect the result.

The two measurements together give the total length.

Chelate Limbs.—On account of difficulty in measuring exactly the total length of the chelate limbs, owing to increasing flexure with successive moults, the length of the terminal pincer joint has been given as a basis for comparison.

A perusal of the foregoing notes will show that my observations on the reproduction of lost parts in the lobster differ in several respects from those previously recorded for the freshwater crayfish. I now propose to discuss shortly the results arrived at.

REPRODUCTION OF CHELATE LIMBS.

My observations on the reproduction of lost chelæ in the

lobster agree in the main with those of Réaumur. The new limb is formed as a protuberance beneath the pellicle enveloping the scar, and, so far as my experience goes, this reproduction always takes place from the basal joint. Réaumur's observations, however, appear to show that in the crayfish, when the new limb has attained a certain development, the membrane enveloping it bursts, and the limb thus set free increases rapidly in size and secretes a shell for itself. In other words, I am led to conclude, from a perusal of Réaumur's paper, that the limb may be liberated prior to ecdysis. I am not aware of any criticism of this view by other investigators, but Chantran would seem to imply that the new limbs are only set free during ecdysis. Huxley, in his work on the Crayfish, also states that the new limb is set free at the next moult, but gives no reason for differing from Réaumur.

In the case of the lobster the limb is undoubtedly set free during ecdysis, and at that time only. The membrane in which it was enclosed remains attached to the exuvium, and though it is frequently ruptured, I am inclined to think that this is sometimes, at any rate, only an accidental occurrence, due to the thinness of the membrane itself. In the young lobsters observed, the rudimentary chela, while still within

point were both males. These facts must be borne in mind, as, according to Chantran's observations on adult crayfish, the male moults twice as often as the female. Although I have no definite information on the subject for the lobster, it appears probable that a similar diversity exists in this species.

In Lobster **B.** the right chela was lost at a time when the left had a pincer joint 3 inches in length. After the next ecdysis the right chela was reproduced, its pincer joint measuring $2\frac{3}{8}$ inches in length. With the same ecdysis the left pincer joint had increased from 3 to $3\frac{3}{8}$ inches in length. After an ecdysis which took place four months later, the left pincer was $3\frac{3}{8}$ inches long and the right $3\frac{7}{8}$ inches. Thus with the second ecdysis the difference in size between right and left pincer joints was reduced from 1 inch to $\frac{1}{2}$ inch. The next ecdysis did not take place until the following spring, eight months after the second. The difference between the two was then reduced to $\frac{1}{4}$ inch, and after a fourth ecdysis during the autumn this difference was maintained.

From these observations we may conclude that in a male lobster, about $7\frac{1}{4}$ inches in length, if one of the chelæ is lost, a period of from sixteen to eighteen months intervenes before the new limb attains its full and normal development for a lobster which in the interval has attained a length of about $9\frac{1}{2}$ inches. These results agree closely with Chantran's observations on *Astacus*.

Growth of Chelæ lost at Different Dates.

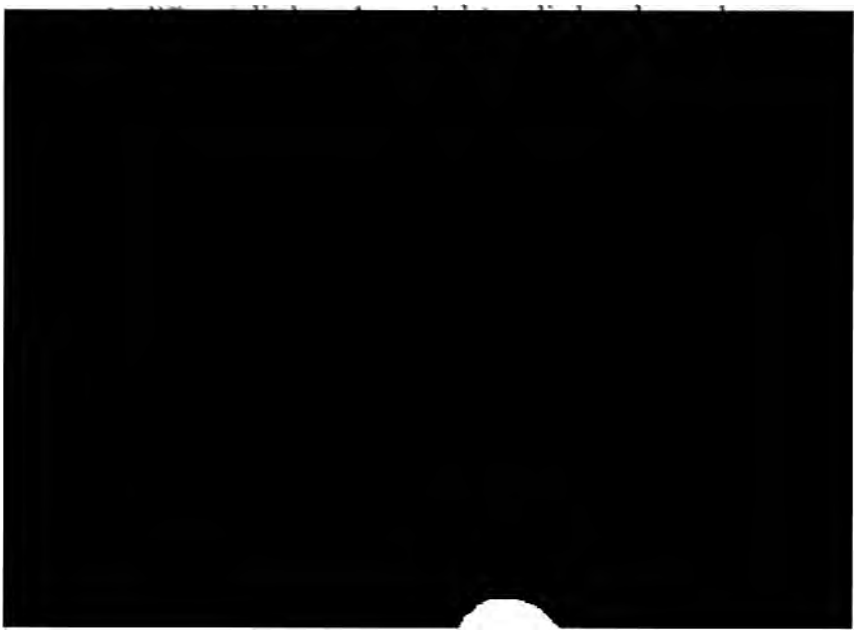
The observations on Lobster **C.** afford interesting information on the growth of chelæ lost at different dates. The left chela was lost 7, xii. 82, and the right 6, ii. 83, practically two months afterwards. In the meantime the rudiment of the left chela made its appearance, and during the following month a similar rudiment was formed on the right side. On 13, iv. 83, the left rudiment was $\frac{1}{2}$ inch long, and that on the right side only $\frac{1}{4}$ inch. During the months of May and June the smaller rudiment increased more rapidly in size than the one first formed, until on 26, vi. 83, both were practically of the same size. A few days later ecdysis took

place, and the pincer joints of the new limbs measured—right $2\frac{3}{16}$ inches, left $2\frac{1}{16}$ inches.

It thus appears that in a case where the two chelæ are lost at different times, and with a considerable interval between, the two new limbs will be reproduced together at the next ecdysis, if a sufficient time intervenes for the development of their respective rudiments.

Reproduction of Ambulatory Limbs.

My observations on the reproduction of ambulatory limbs in the lobster are not in accordance with those of Chantran for *Astacus*. This author maintains that in *Astacus* the ambulatory limbs, like the chelæ, do not attain their full development until the third or fourth ecdysis after their reproduction. Lobster **B.** supplies evidence on this point. A reference to the record of observations will show that after the ecdysis, 19. v. 83, the rudimentary ambulatory limbs became of the same size as their older fellows, while the chelæ required two or three other ecdyses to bring them up to their normal size. This evidence appears to show that in the lobster, at any rate, the new ambulatory limbs attain their full development at the first ecdysis. Indeed, one might be led to expect this from a study of the functions of



ecdysis, but that, like the chelæ, they require to undergo three or four ecdyses before the normal size is reached. Chantran has shown that in the crayfish this is not the case, but that the antennæ are there reproduced of full size after the first ecdysis. According to his observations, the antennæ are the only appendages which are reproduced so rapidly. A difference in species may account for this difference in reproduction. The antennæ of *Astacus* are relatively much shorter than those of the lobster, and so may be capable of attaining their full size after the first ecdysis.

Time occupied in the Reproduction of Lost Parts.

Under this heading I propose to discuss briefly the duration of the period which intervenes between the loss of an appendage and its renovation after ecdysis. There appears every reason to suppose that this period may vary with the season of the year in which such renovation takes place, and its duration is also dependent on the precise time at which loss occurs in its relation to a normal period of ecdysis. If an appendage should be lost shortly before a normal ecdysis, it is reasonable to expect that a new rudiment could not be elaborated with sufficient rapidity to be set free at the following ecdysis. Thus the new appendage would only be formed as a rudiment after the first ecdysis, and be set free at the second moult. On the other hand, if several months intervene between the loss of an appendage and the next ecdysis, the rudimentary appendage usually makes its appearance during this interval, and becomes functional after the first ecdysis.

According to my observations, the antennæ, however, do not appear to be reproduced with the same regularity as the chelate and ambulatory limbs. Thus in specimen **C.** the right antennal flagellum, which was lost during the winter 1882-83, was not reproduced until the *third* ecdysis, whereas the left was reproduced at the first. Whether this occurrence was normal or due to injury, I am at present unable to say; but no injury was noted at the time. Spence Bate (**9**) records a case of reproduction of the flagellum observed by Mr Lloyd in the Hamburg Aquarium, in which the new appen-

dage was liberated at ecdysis four months after loss. He also gives a figure of the coiled rudiment.

With regard to the chelæ, my observations afford precise data in three instances, which are as follows:

LOBSTER **A.**

1. Both chelæ lost 5, iii. 83; reproduced at ecdysis, 25, viii. 83; interval about 5½ months.

LOBSTER **C.**

2. Left lost 7, xii. 82; Right ,, 6, ii. 83; } both reproduced 1, vii. 83; } interval 7 mos. ,, 5 ,,
3. Both ,, 14, viii. 83; both reproduced 25, xii. 83; ,, 4 ,,

It will be noted that in examples Nos. 1 and 2 the chelæ were lost between December and March, that is, at a time when the temperature is low. In these cases the interval was long, averaging nearly six months. In the third example the chelæ were lost in the summer, and were reproduced four months afterwards. The lobster, unlike the crayfish, does not appear to refuse food during any definite period of the year, and, so far as my observations go, only does so for a short time prior to each ecdysis. There does not, therefore, appear to be an alternation of periods of growth and rest as in the crayfish, or, at any rate, these periods are not so well marked. Nevertheless ecdysis appears normally to take place during the spring and autumn

The deep blue of the normal exo-skeleton is the last to appear. It is first seen as faint washes and patches amongst the red about a month prior to ecdysis; and before the old exo-skeleton is cast, the new soft limb has become of the normal deep blue colour characteristic of the living specimen. The red has become entirely, or almost entirely, replaced by blue. The tuberosities of the chelæ, however, retain a portion of the original tint. This order in the development of the various shades of pigment appears to be constant in normal cases.

Rupture of the Carapace during Ecdysis.

Although this subject does not technically come within the scope of the present paper, a few notes on the process, as I have observed it, may help to clear up a subject on which a considerable diversity of opinion appears to exist. Without reviewing the literature on the subject, which is voluminous, the diversity of observation may be summed up in the following question: "During ecdysis does the carapace rupture along the median dorsal suture?" Réaumur and a large number of more recent observers assert that it does, and that on this account the process of ecdysis is more easily accomplished. Others, myself included, have been unable to note any rupture in the cast exo-skeleton. Under date 19, xii. 84 of my notes referring to Lobster **C.**, an account will be found of the condition of the exuvium after ecdysis. There was no rupture of the membrane, but the cement in the dorsal suture had been partially dissolved. On this account the branchiostegites were allowed a certain amount of motion, and as the soft parts were withdrawn, no doubt the membrane lining the cephalothorax became tense to such an extent as to allow the lobster to escape easily from its exuvium. But it must be remembered that this specimen was by no means a large one. The cephalothorax was much thinner than in older specimens. Where the calcareous deposit is comparatively limited, the various portions of the cephalothorax are capable of a certain amount of motion along the dorsal and cervical sutures, which decreases as the shell becomes thicker. Thus, in old specimens with thick shells, a rupture may be

necessary along the dorsal suture before the soft parts can be withdrawn, whereas in younger specimens, with a thinner cephalothorax, the absorption of a portion of the cement of the dorsal suture may be sufficient to allow of the requisite amount of play. Should this be the case, we have a solution of the difficulty, that whereas the cephalothorax splits along the dorsal suture in some cases, it certainly does not do so in others. It appears to me that the same argument applies to the membranous parts of the chelate limbs. Whether or not these rupture during ecdysis, I regard as depending mainly on age. In young specimens the membranes are comparatively thin, and capable of a considerable amount of tension without injury, whereas in older and thicker membranes rupture may take place owing to want of elasticity.

List of References to Literature.

1. Sur les diverses reproductions qui se font dans les Ecrevisses, les Omars, les Crabes, &c. M. Réaumur, *Mém. de l'Acad. des Sciences*, 1712. Paris, 1814.

2. Observations s. l. mue des Ecrevisses. M. Réaumur, *Mém. de l'Acad. des Sciences*, 1718.

3. On the Process of Exuviation and Growth in Crabs and Lobsters.

Explanation of Plate XVII.

Fig. 1. Rudimentary antenna of Lobster **A.**, 29, v. 83 (natural size).

Fig. 2. Rudimentary antenna of Lobster **C.**, 11, v. 83, showing spiral coil (natural size).

Fig. 3. Chelate rudiment of Lobster **C.**, 5, x. 83 (half natural size).

Fig. 4. Anterior portion of Lobster **C.**, 17, xii. 83, showing relative size of chelate rudiment prior to ecdysis (natural size).

Fig. 5. Anterior portion of Lobster **C.**, 25, xii. 83, showing relative size of chelate limb after ecdysis (natural size).

XXX. *Notes on an Indian Water-snake* (Enhydrina Valakadyen). By J. E. H. Kelso, Esq., M.B., C.M.

(Read 16th February 1887.)

On May 14th, 1884, I was returning from a cruise on the river Hooghly in a steam launch, and had brought up at Howrah, a town on the bank of the river opposite to Calcutta. Being low tide, our party was rowed ashore in a dingy, when I observed a crowd of natives on the bank, standing at a respectful distance from an object which they were scrutinising intently. This proved to be a water-snake (*Enhydrina Valakadyen*), several feet long, writhing about apparently in great agony. After looking at it in great astonishment for some time, I thought it better to put an end to its struggles, and so killed it with a walking stick. Examining my specimen, I found two long spines protruding through its skin.

A native now came up from the contemplative crowd already mentioned, and informed me that the spines belonged to a cat-fish. On palpation I made out the contour of a fish in the reptile's interior. I carried the snake home, and preserved it in spirits. The specimen was kept entire for two years, but a short time ago I determined to slit up the snake's abdomen to show the fish it contained. The fish is one of the Siluridæ, about 7 inches in length. The two spines are each $\frac{3}{4}$ of an inch in length; one of them may be seen protruding through the dorsal surface of the reptile at an acute angle, while the other is lying flat, and closely pressed against the snake's abdomen.

It is curious—as Mr Boulanger remarked when I showed him the specimen—that the snake displayed no more discretion than to swallow a fish with such formidable serrated spines; but at any rate, it evinced this amount of discretion that it swallowed its victim head foremost. The large size of the fish in comparison to the narrow head and neck of the snake, clearly demonstrates the enormous elasticity of the swallowing apparatus of these reptiles.

Evidently the snake on swallowing the siluroid tried hard to eject it, the result being that the spines of the latter passed through its captor's abdominal wall; for if the spines had pierced the tissues of the snake from being erected by the fish alone, without any backward movement on its part, they would certainly have caused a rent, while it may be seen they have passed through, causing no linear tear whatever.

Enhydrina Valakadyen is one of the most poisonous of the Hydrophidæ. Mr Boulanger, at the Natural History Museum, South Kensington, showed me a specimen somewhat analogous to mine—viz., a coral-snake (*Elaps lemniscatus*) which had swallowed an Amphisbænoid. The anterior half of the latter is seen protruding through the side of its captor. For an account of this specimen see *Proc. Zool. Soc.*,

In setting about this, it was necessary to bear in mind the following points:

(*a.*) An antiseptic may act in one of many ways—a very minute portion of an antiseptic may prevent the growth and development of a micro-organism in a nutrient medium, but the micro-organism may, when removed from the presence and restraining action of the antiseptic, again begin to flourish and grow. A stronger antiseptic may kill the micro-organism outright, and so on. One must therefore find a method by which one is enabled to determine in what way the antiseptic acts; that is, it must be possible to leave the antiseptic to act on the micro-organisms in one case, whilst in another it must be possible to get rid of the whole, or by far the greater part of the antiseptic, and then see whether the organism will begin to grow or not.

(*b.*) Another point to be attended to, is that during the whole of the manipulation there shall be as little exposure of the materials with which one is working as possible.

(*c.*) The process should be available for use with either fluid or solid media, and the results should be easily observable and readily followed.

The method of procedure I adopt is as follows:—Take two or three dozen test-tubes of exactly the same size (I have found that ½-inch test-tubes 5 inches long are perhaps the best); wash them thoroughly with a dilute acid, then with ammonia, and lastly with distilled water; allow them to dry, plug them with cotton wadding in the ordinary manner, and place them in the hot-air steriliser, where they should be kept for an hour or two at a temperature of 150° C. to 160° C. These are to be kept at hand for use as afterwards described.

If it is wished to use a solid medium, either gelatine or agar-agar may be used, ½-inch test-tubes again being used. The medium may be allowed to "set," with the tube in either the vertical or in the sloping position as required.

If a fluid medium is to be used, the ½-inch test-tubes should be partially filled (2 inches), as in the case where gelatine is used.

Next take pieces of thin glass rod about 5 or 6 inches in length, and into the end of each fuse a piece of thin platinum wire about 2 inches in length, on which have been formed a

couple of loops, one near each end of the wire (Fig. 1, Plate XVIII.). To these loops are tied the ends of short silk threads, so that for the greater part of the length of the wire there is a thread running parallel with it. Around the rod near its upper end wrap a layer of cotton, so arranged that when the rod is introduced into a ½-inch test-tube the wadding acts as a plug. The whole is then sterilised in the hot-air chamber as above (Fig. 2, Plate XVIII.).

Lastly, prepare a few dozen ½-inch test-tubes by washing them thoroughly, then filling them for a couple of inches with distilled water; plug these with cotton wadding, and sterilise them in the steam chamber.

Everything is now ready. Suppose it is wished to determine the action of a solution of some antiseptic on any specific bacterium, say the *Bacterium Termo*. This may be done, either by leaving the antiseptic to continue its action, or it may be allowed to act on the micro-organism for a short time only. In the first case pour a small portion of the fluid in which the *B. Termo* has been cultivated, into a shallow, clean, sterilised dish, which may be covered with a flat plate. Also pour a quantity of the antiseptic fluid to be used into one of the test-tubes previously sterilised, and replace the plug. Now withdraw one of the wires from its test-tube,

used, it exerts any deterrent action on the growth of the micro-organism.

If, however, it is desired that the effects of a re-agent acting for a short time only should be determined, the method of procedure is as follows:—After allowing the thread to remain for the specified time in the antiseptic fluid, it is transferred to a test-tube in which the sterilised distilled water has been prepared. Here it is well shaken up, and then allowed to remain for five or ten minutes, after which it may be passed through one or two other waters in just the same fashion. It is then transferred to the nutrient medium, and carefully watched from day to day.

Whichever method be used, control experiments must always be carried out. A thread must be passed through the solution of micro-organisms, and then into a nutrient medium. Other threads should be passed through the *B. Termo* solution, then through one, two, three, or even more distilled waters, as may be thought necessary, and then into the nutrient media; and the growths resulting in all these cases should be compared, both as regards rapidity and luxuriance, with any that may appear in the other experimental tubes.

The results obtained in a large number of experiments have proved most satisfactory, and in all it has been demonstrated that the method has the following advantages. The apparatus required is comparatively simple and easily obtained or manufactured. The various re-agents, etc., being placed in tubes of the same size, and the glass rod which carries the wire having its own plug attached, the thread can be transferred from medium to medium with great rapidity, and with little danger of coming in contact with other foreign particles, so that the thread is never touched by anything except the materials with which we wish it to come into contact. No extra wires, no forceps, or anything are necessary. The thread may be plunged into a mass of nutrient jelly or fluid, so that the growth may take place along the track of the needle and thread, or it may be allowed to lie on the surface of agar-agar or gelatine, and a surface growth may be so obtained.

By using flasks, the necks of which are the same size as the bore of the test-tube, the action of gases on micro-organisms may be determined; and with other slight modifications, which are at once apparent, the method may be adapted for the action of heat, modified or increased pressure conditions, and so on. So far, I have had extensive experience of the use of the method with fluids only, but that has been in all cases most satisfactory. The small number of experiments where gases, heat, etc., have been employed, have, however, given most encouraging results.

Explanation of Plate XVIII.

Fig. 1. Glass rod, with platinum wire and thread (*c*) attached to loops (*d*, *d*).

Fig. 2. Test-tube containing nutrient jelly, into which is introduced the glass rod (*a*) surrounded by plug of cotton wadding (*b*). Fused into the end of the rod is the platinum needle (*c*), with a couple of loops (*d*, *d*), to which are attached the ends of silk thread by single knots.

PROCEEDINGS

OF THE

ROYAL PHYSICAL SOCIETY.

SESSION CXVII.

Wednesday, 21*st December* 1887.—Professor DUNS, D.D., F.R.S.E., Vice-President, in the Chair.

The CHAIRMAN delivered the following address:

GENTLEMEN,—This is the third occasion on which I have had the honour to deliver the Address from the Chair at the opening of a new Session—twice as President, and now as retiring Vice-President. In 1870-71, the centenary Session of the Society, the Address was devoted to a sketch of the life and work of Sir James Y. Simpson, a former President, and to an attempt to estimate the value of the discoveries in marine zoology of Dr Thomas Strethill Wright, also a former President, who at the time was still spared to science, but whose original observations were somewhat unfairly being accredited to others. In the Address at the opening of Session 1880-81, the subject dealt with was "The Beginnings of Scottish Natural Science,"—running the lines of observation and discovery up to 1684, the date of Sir Robert Sibbald's great work, "*Scotia Illustrata*," and using the occasion for a sketch of Sibbald's life. I refer to these matters mainly to get an opportunity to say, that when called to face the duty of this evening, I thought it might be both profitable and stimulating to devote the present address to an outline of the life of our late distinguished

Secretary, introductory to an estimate of his contributions to Scottish ornothology. But as the materials for this were not so readily available as had been thought, the intention was given up. Reference will, however, be made to him in another connection.

In the course of the present year the Society has lost by death several highly esteemed Fellows,—two of whom had laboured long and earnestly, and with rare devotion, in its interests; and other two who, though seldom at our meetings, deserve some notice.

1. George Freeland Barbour, Esquire of Bonskeid and Gryffe, was born in Glasgow in 1810, and died at his town residence, 11 George Square, Edinburgh, in January last. He was educated in Glasgow. After attending the arts' course in the University of Glasgow, he went to Manchester, where, with his brother, the late Robert Barbour of Bolesworth Castle, Cheshire, he founded the well-known mercantile firm that still bears their names. In 1846 he retired from business, and came to dwell in Edinburgh, where he was soon widely known as a cultured Christian gentleman, ever forward in works of religious beneficence and practical philanthropy. Mr Barbour joined this Society in 1849. He was also a Fellow of the Royal Society of Edinburgh. His shrewdness, sagacity, strong common sense and first-rate

2. William Brown, F.R.C.S.E., F.R.S.E., F.S.A.Scot., was born at Edinburgh in 1796, and died in January 1887. He had dropped out of our list of Fellows a good while before his death, but, remembering his presence here when I first became a Fellow, and having a very pleasant recollection of a Paper read to us, and printed in our *Proceedings*, I was unwilling to leave out his name from this address. He was the son of William Brown, M.D., F.R.C.S.E., an Edinburgh practitioner. Mr Brown himself practised as a medical man in Edinburgh from 1817 to 1884, when he retired. An old friend, John Stuart, Esq., W.S., says of him, "I have had occasion to peruse a great deal of his correspondence, and though I knew Mr Brown from my infancy, I was astonished to learn how wide his sympathies were, how large a number of subjects of a great variety of kinds he was well informed in, and how tolerant he was of opinions with which he did not agree." In an interesting biographical notice by Dr Lowe, of the Edinburgh Medical Missionary Society, the following paragraph occurs,—"Mr Brown especially identified himself with the furtherance of the cause of Medical Missions. At the inaugural Meeting, held in 1841, he was elected a Director; and in 1849, on the death of Dr Beilby, he became president of the Society, which office he retained till his death."

A good idea of Mr Brown's habits of observation and research may be got from two of his Papers—one read to this Society, March 28, 1866, and another entitled "Notes and Recollections of the Tolbooth Church." The former is a model animal biography; the latter is brimful of antiquarian gossip. Mr Brown was a man of great simplicity of character, and never seemed happier than when helping others. "He had a good report of all men and of the truth itself."

3. By the death of Mr Robert Gray, late V.P.R.S.E., F.S.A.Scot., etc., we have sustained a loss so great that it can hardly be put in words. About the only element of rest in looking at it, as scientific workers, is the consideration that so long as there is devoted and self-denying work to be done, all the past warrants the anticipation that there will be agents to do it. Mr Gray was a model Secretary—a man

of affairs, frank, genial, wide of view, with a taste, I had almost said a greed, for details, untiring zeal, and a patience which trial only strengthened. The Society has been singularly fortunate in its secretaries. Three names stand out in its recent annals—Wyville Thomson, John Alexander Smith, and Robert Gray, each of whom devoted much time, excellent business talent, and varied attainments as naturalists to the interests of the Society. All were enthusiastic men of science; each, however, had his specialty, but each was free from the narrowness and very limited outlook which are so often the accompaniment of mere specialism, because each had learned, that all the things in the great field where their specialty had found them, are more or less closely related. Thus their wide sympathy with, and their intelligent interest in, workers of all sorts in these departments which chiefly occupy the attention of this Society. Themselves unselfish, earnest workers, they could rightly appreciate painstaking industry, and unflagging effort, even in those whose happiness almost seemed to lie in going out of their way to let the Secretary know that they had little respect for *his* phase of observation and research.

Mr Gray was born, and as a boy was educated, at Dunbar. He early entered the service of the City of Glasgow Bank, which, after a time, he left for that of the Bank of Scotland

"These prices," he once said to me, *apropos* of the extravagant sums that were being paid for books selling at the time in London, "are enormous. I would like to have the books, but, only think of it! one's library would need more watching than the bank."

But it was as a distinguished, scientific ornithologist that Mr Gray was best known, and as such he will continue to be remembered. His off-hand notices at this table of rare species and varieties, but chiefly his "Birds of the West of Scotland," bear emphatic testimony to his sterling qualities as a naturalist, to the breadth and balance of his mind as an observer, and the fulness of his furnishing in the systematic knowledge and the literature of ornithology as an author. His descriptions are as clear and crisp as definitions. The work abounds in proofs of his extensive information, keenness of eye, discriminating judgment, long familiarity with the habits of birds in their favourite haunts, and of a memory singularly retentive, even of minute, specific, and variety features. All this could not fail to make Robert Gray what he had become,—a foremost authority in recent Scottish ornithology.

4. To institutions as to individuals adverse circumstances seldom come singly. The remark has become trite by being in experience so often true. It has been so with our Society. The loss sustained by the death of our Secretary is intensified by that of his assistant, Mr John Gibson, of the Natural History Department of the Museum of Science and Art, a comparatively short time after. Mr Gibson was admitted a Fellow in 1869, Mr Gray in 1874. Mr Gibson was an accomplished student of natural science, a man of exact business habits, with a mind stored with the facts of several branches of science. He was in every way peculiarly well qualified to act along with Mr Gray in conducting the business of the Society. Holding a position in which accuracy of detail must keep in line with much general knowledge, Mr Gibson had rapidly ripened in qualities which not only made him a most intelligent expert in his proper work, but which fitted him for the popular interpretation of science, for divesting its facts of a somewhat forbidding, but for

purely scientific purposes, necessary terminology, stating them in good Saxon speech, and bringing them within the ken of that great constituency whose information is so often far ahead of their education, and who really form the chief strength of the state. In the midst of the engrossment of his daily avocations he had already done much in this direction, and had given large promise of much more. I regret that almost my only intercourse with Mr Gibson was in this room, before and after the meeting of the Society. Occasionally we walked part of our way home together, and at such times I was struck with his quiet and retiring disposition, and with the happy knack he had of referring to views from which he differed, without the least bitterness or want of charity to those who held them. I once heard Sir James Simpson say of a thoughtful medical man who died young,—"He was *older* than some of us that are twice his age!"

> "We live in deeds, not years; in thoughts, not breaths,
> . . . . . .
> . . . . . He most lives
> Who thinks most, feels the noblest, acts the best."

Mr Gray and his assistant both joined the Royal Physical when it was in the heart of one of those conditions of decline, to which most institutions that are not buttressed by endowments and an unfluctuating annual income are

Young, have M.D. added to their names; the other sixteen, Thomas Melville, Thomas Smith, James French, James Wood, Robert Stewart, Alexander Muir, James Dick, Henry W. Tytler, Malcolm Macqueen, Arthur Taafe, Daniel Gibb, Thomas Thorburn, James Webster, George Horne, William Manuel, and William Keir, have no designation. The times were stirring in science, and their influences were bearing in on the minds of the young. In 1788, the Society assumed the title "Royal" under charter granted by the Crown. The membership had meanwhile increased, and was bulking out in the eyes of students. Thus between 1771 and 1788 we find such names among its Fellows as Benjamin Bell, Alexander Monro, J. Hope, Joseph Black, Frances Horne, James Gregory, etc. Ever since its foundation it has, as it does now, stood in close relations to the University. Thus many of the University Professors have occupied its chair, and through them and under other influences many students were enrolled as Fellows, who having completed their curriculum removed to other localities, or left Britain for positions of influence abroad. Out of sight out of mind. Their names gradually dropped from the list of Fellows, and the funds of the Society suffered in consequence. It is not alleged that the fact referred to here is the only cause, though a true one, of the difficulties into which as a Society we have periodically fallen. In other departments than those with which we specially concern ourselves corresponding experiences have a place. Revivals often come apparently unasked for, and are succeeded by periods of reaction earnestly unwished for. What the principles are that underlie these, and the forces which determine them, are far from plain. They can only be obscurely guessed at. But, waving all speculation as to this, I am anxious to give prominence to the origin and cause of one tendency which has been influential throughout the long period of our history, and which operates still, and is still as in the past apt periodically to become acute. Is there a remedy? When Mr Gray became Secretary he set himself to neutralise the tendency and to provide a remedy. This he saw could only be done in one way, so long as there was no reserve fund to draw on till

the crisis passed. This was by a large increase in the number of Fellows; and this he kept before him and tried to press persistently on others, throughout the period of his busy, painstaking, enthusiastic, and consequently, as far as numbers went, successful efforts. This seems to me to be one lesson to be learned from his work *qua* Secretary. But there is another side to this. Several years ago I took occasion, when congratulating him on the appearance of a billet containing an unusually large number of names of candidates, to point out that several of these were names of men who were hastening to win their spurs in a noble race, and would no doubt favour us with papers of much scientific value, but would expect them printed *in extenso*, and even, perhaps, illustrated at the Society's expense. "Do you as a banker," I said, "think that the comparatively small annual fee will suffice for this?" "I hardly think so," was his reply, "but we must try and get more, and hope the best!" Now here we have the very men of whose Fellowship this or any learned Society might be proud, by their accession to our numbers either doubling our publishing account, or coming to entertain feelings of disappointment in not having their Papers fully and speedily printed. Is there a remedy? I have said we have no endowments. When honoured recently by Dr Gunning, a Fellow and former President of

branches of study and research. This has in the past marked the whole history of the Society. It was here that Simpson and Carpenter, and Edward Forbes and John Goodsir, and Wyville Thomson and Strethill Wright, and others, planted their feet on the first rungs of that ladder on which they climbed so high! And that this feature of our influence and usefulness is as broadly marked at present as it ever was, is beyond all doubt. "There were brave men before Agamemnon," and there have been many since. I could name a goodly band of young workers among our Fellows, even fuller of promise than the distinguished men just named were at a corresponding time in their career, from whom we are entitled to expect much, and from whom already we have got much. Should we not then bestir ourselves, and insist on sharing in any grants made by the State for the encouragement and promotion of Scottish science?

Perhaps the interests of Scottish science have suffered from want of united effort on the part of our learned Societies. I have a strong conviction, that if we were to present a united front to the age, we would have far more influence than we have at present with the government of the day, and far more influence also in determining and guiding the *zeit geist*—the temper of the time—on the side of the interests of science. Were the Royal, the Royal Physical, the Botanical, the Geological, the Meteorological, and the Royal Geographical federated under the designation SCOTTISH ACADEMY OF SCIENCES, the position of cold isolation in which they severally stand to each other would be removed, and united action could readily be taken, whenever the interests of all, or of any one, demanded it. But incorporation would frustrate the ends in view. Thus each would preserve its own funds, elect its own council and president, meet and transact its business under its own council as at present, and let the several councils be the constituency for electing a distinguished man of science, of letters, or of rank, as President of the Academy.

Now this may all seem little likely at present, but certainly it is not less likely than the fruit of Fleming's sug-

gestion, made in the Address delivered by him at the opening of our Society in Session 1849-50, when he so earnestly urged the duty of steps being taken by our public bodies and others to bring under the notice of Government and the country the want of a National Museum for Scotland. It was the Royal Physical that took the first well-defined step towards the realisation of the Museum of Science and Art.

The scheme thus presented in broken outline may seem vague enough, but it is not fanciful. And, I am quite sure, that to present it, so as to set it before you as if in working detail, would show that it has advantages both as regards the actual work of science, and the influence of science on public thought and the public interests of the time, as might make it to be desired by most who take a hearty and intelligent interest in them.

But, drawing back from such a far outlook, let me glance, if only at the surface of some of the active influences in the midst of which we at present work—influences which, whether we will or no, colour our views, for even those of strongest will and steadfast self-reliance cannot wholly resist the power, fascinating or repellant, of environments. We may be ever on the alert to banish bias, and may succeed in satisfying ourselves that we have done so. But this may be the surest proof to others of utter failure in this direction

logic dealt have been set in other, their true relations, by the discovery of new facts. Strong confidence in speculative views then current has given place to hesitancy; generalisations held unassailable have been found unwarranted by the data appealed to in their behalf; progress has been setting up its way marks by the explosion of old errors and the revival of long-neglected truths; knowledge has increased; the domains of science have been increased and widened. Old facts have been, and are being, set in new relations, and in the altered relations they stand out in new and striking lights. Things but recently undreamed of have become common-place realities. Aspects of thought which a few years ago were no more than the bodying forth of strong imagination, are now current as undisputed truths. It is well if honest workers can in the midst of such changes keep the heart and the habit to assimilate the elements that have become potential by the new circumstances and the new relations, and all through the changes retain not identity only, but power also—power to swim against any tide which would sweep from them that consciousness of manly individuality, and that force of free will, which are their heritage as true men. Dead fish swim with the tide. And if workers, especially young workers, so many of whom are on our roll as Fellows, may hope to keep clear of that rapid speculative rush which at present meets us in biology, it will only be by unswerving homage both to the laws and the limits of true method—painstaking observation in order to legitimate inference, and inference in order to deduction, or the exhibition of law.

Writing in July last, Max Müller said, "Definition is the only panacea for all our present philosophical misery." But the first step towards a definition of several most vital points in current biology shows definition itself to be impossible, because all workers acknowledge that the points themselves suggest relations that are not yet thoroughly known. And the consequence too often is a crop of mere assumptions for which there is no warrant but a subjective one—the mental bent of the student. Thus amidst all the lavish riches of recent science, and even the clear exhibition of true method,

you have to face no end of assumptions in support of which assertions are substituted for true evidence. "The shadows of the night are projected into the noon." The speculative rush deepens, and

"Nunc ratio nulla est restandi, nulla facultas."

Thus the attention of students is in danger of being turned away from solid and profitable work, and substantial progress is greatly hindered. It would, indeed, be absurd to attempt to divorce philosophy from observational branches of science. This is beyond our power. But, were it within our power, it would be most undesirable. Because it is when observation allies itself with philosophy that bare knowledge becomes vitalised, that the thoughts which underlie phenomena become as real to us as our own thoughts are, and that we get in touch with the very highest function of philosophy itself, that, namely, which brings to the front the all but universal conviction that the laws which determine and control the inter-dependencies and inter-relations of being are the fruit of personal thought and forethought. But, even assuming all the advantage held to lie in this, it is still true, that much of the present unrest among students touching life and its modes of manifestation is to be traced to the increase of generalisations in these subjects, whose data are part observational and inductive and part speculative

until lately, when my friend, Mr Harvie-Brown, suggested that I should re-write them in a more permanent form, and at the same time allowed me to use his notes.[1]

About four in the morning of June 23, 1883, we found ourselves becalmed about four miles to the north of the outermost of the Ascrib Islands; so after breakfast the dinghy was lowered, and I landed, with two of the crew.

The Ascrib group forms an irregular chain of islets, the general direction being about north-north-west and south-south-east, or, roughly, north and south by the compass. The two ends of the chain curve slightly to the west. The group is situated near the entrance of Loch Snizort, and lies a little nearer to the west side than to the east.

We pulled for the outermost—Eilean Eashal—and landed, but did not stay very long, as the birds observed were not of special interest to me, as I wished, if possible, to procure the eggs of *Procellaria pelagica*, which bird, I learned, bred on the Ascribs, and the next island looked more likely breeding ground for it. All round Eilean Eashal, at high-water mark and above it, were immense quantities of boulders and slabs of rock, from under which I took a few black guillemots' eggs, of which species there was a large colony. Mr Harvie-Brown paid much more attention to this island than I did, and more especially to the enormous number of black guillemots which breed there. He says: "I counted round the shore of No. 1, 141 birds (black guillemots), and very few, if any, of these were counted twice over, as they move very little from one part of the coast to another, but keep to their own breeding grounds. In one bay I counted 37. If, say, 141 more birds are supposed to have been sitting on their eggs among the stones, we may safely reckon the colony at 130 pairs on No. 1 alone." This island is not high, rather flat, and covered with grass, as are all the others, except the mere skerries.

Leaving this island, we pulled for the next one in the chain—Eilean Craigeach. This is a larger island than the last, with a rounded grassy hill near the centre, rising to a moderate elevation. It is elongated in shape. Mr Harvie-

[1] He visited the islands in 1884.

Brown estimated its length at half a mile, and it seemed to me to be about a quarter of a mile wide. There are cliffs on the north-east side and also on the south-west. I at once "made tracks" for the rounded hill before mentioned, and finding a burrow of some sort on the western slope, I commenced digging with my hands, because I had found at Rona that this was the best way of discovering petrels' breeding haunts. An old sheath-knife or piece of stick is a great help, but a spade breaks too many eggs. The burrow I was working at looked like a puffin's or a rabbit's, but I soon found that small burrows, like rat-holes, branched off from the main one in all directions. After about half an hour's hard work I found a storm petrel, but no egg. I persevered, and finally, after digging out about half a dozen birds, I was rewarded by finding an egg. I then moved round to the northern slope of the hill, and when the two men joined me, we all set to work at another large burrow, and after some hours' hard digging, the total bag amounted to only four eggs, although we had dug out over twenty birds, which we let away. These birds are much more lively when just taken out of their burrows than is the case with *Procellaria leucorrhoa*, the former biting and scratching and squirting oil through their nostrils with great vigour, while specimens of the fork-tailed petrel struggle little, and generally content

saw a female of this species on Eilean Eashal, or No. 1, counting the islands from the north end.

2. *Anthus obscurus* (Lath.)—Rock Pipit.—This species was moderately common on all the islands.

3. *Sturnus vulgaris*, Linn.—Starling.—Harvie-Brown says of this species, "a few pairs breed; broken eggs found." I suspect that the nests were placed among the stones and rubbish on the cliffs of Eilean Craigeach, or No. 2 from the north, although I did not see them.

4. *Corvus cornix*, Linn.—Hooded Crow.—Harvie-Brown saw two "very much bullied" by the lesser black-backed gulls. The hoodie is an inveterate egg-stealer, and is generally to be found haunting the breeding stations of many of our sea-birds. I have frequently seen it breeding in the midst of a colony of other birds. On a small island in the fresh-water loch above Loch Eynort, in Uist, where there is a large colony of lesser black-backed gulls and grey-lag geese, I have seen the hoodie's nest placed on the ground. On Loch Samalaman, in Moidart, there is a large colony of greater black-backed gulls, and another of herons, and every year there is at least one hoodie's nest in the heronry; nor do the hoodies live at peace with their neighbours. I have seen aerial battles between them each time I have been there.

5. *Phalacrocorax graculus* (Linn.)—Shag.—Harvie-Brown noticed a small colony on the east side of Eilean Craigeach.

6. *Columba livia*, Bonnat—Rock Dove.—I noticed two flying about the cliffs on the north-west side of Eilean Craigeach.

7. *Hæmatopus ostralegus*, Linn.—Oyster Catcher.—Common on all the islands, screaming overhead the whole time of my visit.

8. *Strepsilas interpres* (Linn.)—Turnstone.—I did not see any during my visit, but Harvie-Brown saw "one pair in full breeding plumage (17th June), but there was nothing in their actions or behaviour to lead me to suppose that they were breeding. They were very tame and very indifferent. I searched a long time in the most suitable ground just above high water mark, but found nothing."

On 31st May 1880, I saw turnstones on the island of Hysgeir off Canna, and on 8th June 1883, while rowing off to our yacht the "Medina," from the same island with Mr Dalgleish, we saw four or five turnstones sitting on a point. I shot one, which proved to be a female not quite in full breeding plumage.

9. *Totanus hypoleucos* (Linn.)—Common Sandpiper.—Harvie-Brown mentions having seen two during his visit.

10. *Sterna macrura*, Naum.—Arctic Tern.—Colonies bred both on Eilean Eashal and Eilean Craigeach, and Harvie-Brown took eggs from the little island No. 4.

11. *Larus canus*, Linn.—Common Gull.—Observed on both visits, being very abundant in most of the islands, but more particularly on Eilean Eashal. At the time of Harvie-Brown's visit the nests had been newly harried by the lobster fishermen, and consequently comparatively few eggs were found.

12. *Larus argentatus*, Gmel.—Herring Gull.—Moderately common on all the islands, but chiefly on Eilean Craigeach, from the cliffs on the north-west of which I took some eggs.

13. *Larus fuscus*, Linn.—Lesser Black-backed Gull.—Decidedly more common than the last-mentioned species

16. *Alca torda*, Linn.—Razorbill.—Harvie-Brown speaks of the razorbill as "common to the exclusion as far as we could see of the guillemots, occupying the broken and irregular sea-cliffs, especially on the east side of No. 2 (Eilean Craigeach). I counted twenty-three in the air at one place at the same time."

As far as my own observations have gone, they incline me to the belief that the razorbill builds or rather lays its eggs on lower and less perpendicular cliffs than the guillemot, although it is also found associating with the latter at all the great breeding stations.

17. *Uria grylle* (Linn.)—Black Guillemot.—This bird was very common on all the islands, but, as before stated, it simply swarms on Eilean Eashal. Harvie-Brown estimates the number of black guillemots breeding on the Ascrib Islands at 250 pairs, and I cannot say that I think the estimate too high.

18. *Fratercula arctica* (Linn.)—Puffin.—Common upon both Eilean Eashal and Eilean Craigeach. On the former it was to be found among the black guillemots under the slabs and boulders that fringe the island; on the latter, where it was much more abundant, it bred in holes in the grassy ledges of the cliffs, also about their tops. They have assisted in the extermination or decrease of the storm petrel on the South Ascrib, as Captain Macdonald informed Harvie-Brown.

Obs.—Harvie-Brown saw some ducks, but, owing to a haze which prevailed at the time, they could not be satisfactorily identified.

XXXIII. *On the Structure of the Graafian Follicle in* Didelphys.

By Frank E. Beddard, Esq., M.A., F.R.S.E., Prosector of the Zoological Society, and Lecturer on Biology at Guy's Hospital.

(Read 18th January 1888.)

The earliest memoir known to me which deals with the structure of the ovarian follicle in marsupials is a recently published account[1] of these structures by Mr Poulton. This

[1] The Structures connected with the Ovarian Ovum of Marsupialia and Monotremata (*Quart. Journ. Micro. Sci.*, 1884, p. 1).

paper contains a description of the microscopical appearances of the ovary of *Phalangista vulpina*, which is all the more reliable for being the outcome of a study of fresh material.

The *ova* themselves do not seem to differ materially from the ova of other mammalia, except of course from the remarkable ova of the Monotremata figured and described in the same paper;[1] but the *follicle* shows certain peculiar features of interest, which, however, as I shall show in the present paper, are not found in all marsupials, but are wanting in the opossum. Mr Poulton very naturally surmised that his description of the ovum and its follicle in *Phalangista* would "prove to be characteristic of the order."

The youngest ova of *Phalangista*, as of mammals in general, are surrounded by a single layer of flattened epithelial cells. These multiply and form a "granulosa" several cells deep. The first appearance of the liquor folliculi is perfectly normal; it appears as a coagulated (by alcohol) mass between the cells of the follicle on one side of the ovum; between this fluid mass and the follicle cells next to the limiting membrane of the follicle is a layer of altered follicular cells, which have become swollen, are unstained, and have no distinct nucleus. In later stages the whole follicle increases enormously in size; the ovum is in the centre of the follicle,

If I understand Mr Poulton rightly, he wishes to compare the central substance with the liquor folliculi of the ordinary mammalian follicle; but to insist upon its difference in structure, and upon the fact that the ovum is imbedded in it directly through the gradual metamorphosis and disappearance of the surrounding cells which form the liquor.

More recently[1] Mr Caldwell has dealt with the same subject; his observations refer to the ovary of *Phascolarctos cinereus;* the originally single-layered follicle becomes several rows deep, and a cavity appears between the cells; this ultimately spreads all round the ovum, which comes to lie isolated in the centre of the follicle, but surrounded by an epithelium several layers deep; the liquor folliculi contains numerous branched cells, which connect the epithelial lining of the follicle with that surrounding the ovum.

Finally, I have to record that in the opossum (*Didelphys*) the structure of the follicle is slightly different from that of *Phascolarctos;* it shows, in fact, no differences that I could detect from the ordinary mammalian Graafian follicle; the ovum lies eccentrically, and is surrounded by a single layer of follicular cells; this is connected by a bridge of cells with the layers which line the follicle; the interspace is occupied by the liquor folliculi, which appears to resemble the liquor folliculi of placental mammals generally.

Didelphys therefore agrees more closely with *Phascolarctos* than with *Phalangista.*

Now it is probable, on *a priori* grounds, that the follicle of the Marsupialia would indicate a stage in the evolution of the typical mammalian Graafian follicle from the primitive Graafian follicle of the Monotremata. Caldwell has pointed out in the memoir referred to that the ovum in *Phascolarctos* is to a certain extent intermediate between the large yolked telolecithal monotreme ovum and the alecithal placental ovum; this is seen in the phenomena of segmentation; the first two segmentation furrows fail to divide the ovum; and this "shows that although the ovum has nearly regained its original alecithal condition, it still retains the secondary arrangement of protoplasm induced by the yolk of its more

[1] *Phil. Trans.*, 1887.

immediate ancestors." He makes no remarks, however, upon the evolution of the follicle.

Poulton is led by his results to the belief that "there are important distinctions between the Graafian follicle of a marsupial and those of the higher mammalia, and yet these distinctions are by no means in the direction of greater simplicity in the former, but rather the reverse." And again he expresses the opinion that the structure of the marsupial follicle shows no indications of any transition between the Monotremes and Placentalia.

The function of the follicular epithelium is universally admitted to be a nutritive one. Limiting ourselves to the mammalia, Heape and Caldwell have demonstrated the continuity of the follicular cells with the ovum by means of fine processes which perforate the egg membrane. And this has been shown to be the case by Balfour and others in other groups of the animal kingdom; there is, however, some difference of opinion as to condition in which the nutritive matter is passed from the cells of the follicle to the ovum. Caldwell agrees with others in the belief that (in Monotremata and Marsupials) yolk particles are formed first of all in the cells of the follicle and then pass into the ovum, where yolk is also independently formed. Balfour appears to have held the opinion that the nutritive matter

comparatively little, the follicular layers would still form a continuous coating to the ovum, completely filling up the space between the ovum and the walls of the follicle; at first sight there appears to be no reason why the follicular epithelium should not go on increasing, as the ovum diminishes in size, and that the typical mammalian follicle should not consist of a solid mass of cells. But as the follicular cells increase in number, those most distant from the periphery of the follicle, and therefore from the blood capillaries, will not obtain a sufficient food supply, and will therefore degenerate. This process appears to me to have *just* set in in *Phalangista; the follicle of this marsupial nearly represents the hypothetical intermediate condition between the Monotremata and the higher mammals.* Poulton speaks of the gelatinous nature of the mass formed by the degeneration of the follicular cells, which distinguishes it from the liquor folliculi of the higher mammals. This seems to me to show that the gelatinous substance is nearly, but not quite, inert matter; it is in fact a stage in the conversion of the follicular cells into liquor folliculi; the viscidity of the protoplasm still remains. On this view, however, it would be difficult to account—not for the growth of the ovum, because *it* can absorb nutritious matter from the layer of follicular cells round it—but for the persistence of those very follicular cells; the follicular cells acting as an intermediary between the blood and the ovum must be themselves nourished by the blood. Mr Caldwell, however, has removed this difficulty by the discovery, that in *Phascolarctos* the follicular layers immediately surrounding the ovum are connected by bridges of cells with the peripheral layers of the follicle; the same thing may possibly occur in *Phalangista.* A struggle for existence among the cells of the follicle determines which cells are to survive for this purpose. In *Phascolarctos,* however, the follicular liquid exhibits the characters which that fluid exhibits in the higher mammals; it is an inert nitrogenous fluid. It is often stated that the liquor folliculi is shed out by the follicular cells; but it is necessary to assume for the present argument that it is produced by the direct metamorphoses of the follicular cells,

which have become too numerous to secure for themselves an adequate nutritive supply; this is not really an assumption, for Waldeyer distinctly states that this is the mode of formation in Placentalia; I can confirm this statement by some observations of my own upon the ovary of the Potto; in the ripe follicles of this animal, the liquor folliculi contained numerous nuclei which seem to be identical with the nuclei of the follicular cells, and were presumably set free by the dissolution of the cell protoplasm.

The follicle of Phascolarctos *is intermediate between that of* Phalangista *and that of* Didelphys *and the higher mammals generally.* It is like *Phalangista* in the central position of the ovum; it is like the higher mammals in the complete conversion of the superfluous follicular cells into an *inert* liquid. It is a very slight step from this point to the follicle of the higher mammalia.

There is thus some evidence that the marsupials are intermediate between the Monotremata and the higher mammals, not only, as Caldwell has pointed out, in the structure and development of the ovum, but also in the structure of the follicle.

XXXIV. *Notes on Carboniferous* Selachii. By Dr R. H. Traquair, F.R.S., F.G.S.

There are two exceedingly well-marked species of common occurrence in the British and Irish Carboniferous Limestone, namely *C. mirabilis*, Ag., and *C. striatus*, Ag. *C. marginatus*, Ag., I also believe to be a good species, as well as *C. Milleri*, Ag. On *C. acutus*, Ag., *conicus*, Ag., *basalis*, Ag., *Hibberti*, Ag., and *parvus*, Ag., I offer no opinion, not having seen the types; but as to the new species added by Mr J. W. Davis in his large work on the fossil fishes of the Carboniferous Limestone series of Great Britain,[1] there is scarcely one which will stand the test of careful comparison with the common species described by Agassiz. *C. Hornei*, Dav., *C. elongatus*, Dav., and *C. curtus*, Dav., are in my opinion simply synonyms of *C. striatus*, Ag.;—*C. mucronatus*, Dav., and *destructor* Dav., of *C. mirabilis*, Ag. It is rather difficult to give any opinion upon *C. curvus*, Davis.

In the Edinburgh Museum, and in the collection of the Geological Survey of Scotland, there are a few teeth of what is evidently a new species of *Cladodus* from the Lower Carboniferous rocks of Eskdale in Dumfriesshire, though I refrain on the present occasion from giving it a name. In these teeth the surface of the cones is perfectly smooth and glossy, and in the absence of striations they approach *C. van Hornei* and *prenuntius* of St John and Worthen. The thought has struck me,—is it possible that this undoubted *Cladodus* may represent the dentition of *Ctenacanthus costellatus*, the unique specimen of which, with the spines *in situ*, occurred in the same beds? It will be recollected that the only tooth visible in the specimen of *Ctenacanthus costellatus* was an imperfect one, but its one visible cusp was smooth. If there is any connection here, the specimen of *Ctenacanthus costellatus* must have been a young individual, as these teeth indicate a fish of much larger size.

This brings up once more the question of the correlation of *Cladodus* and *Ctenacanthus*, a question which I must admit is still involved in great obscurity. When I wrote my description of *Ctenacanthus costellatus*,[2] I was inclined to believe that *Ctenacanthus* and *Cladodus* represented the spines and teeth of the same genus, and that the genus

[1] Trans. Roy. Dub. Soc., 1883. [2] Geol. Mag., Jan. 1884, pp. 3–8.

itself was Hybodont. Mr Garman, however, in his paper on *Chlamydoselachus*, disputes that view, and claims that remarkable recent shark which has only one dorsal fin, and no spines at all—a form placed by Dr Günther in the family Notidanidæ—to be the modern representative of the ancient Cladodonts. It is perfectly true that the small teeth towards the angles of the mouth in *Chlamydoselachus*, when seen from the front, strongly resemble those of *Cladodus*, yet this resemblance is not very apparent in those which cover the greater part of the jaws, while the bases of the teeth are to my eye strikingly dissimilar. I cannot, therefore, without further evidence, accept Mr Garman's very confident assertion that *Chlamydoselachus is* a Cladodont, leading as it does to the inference that *Cladodus* had no dorsal spines. That *Cladodus* at all events is not quite so close to *Chlamydoselachus* as Mr Garman believes, is, I think, fully shown by a remarkable specimen from the Carboniferous Limestone of East Kilbride, Lanarkshire, which has been lent to me for description by its possessor, Mr James Neilson, of Glasgow.[1] This specimen was recovered from the quarry in separate pieces by the late Mr A. Patton, who, I understand, did not feel sure that they all belonged to the same specimen. However, the fragments were pieced together by Mr Neilson, and after a most careful

shoulder girdle, and evidently represent the propterygium and metapterygium of ordinary *Selachii*. Behind these is an oblong metapterygium, bearing radials preaxially, whose anterior portion seems to have absorbed the bases of one or two adjacent radials, but whose posterior extremity is continued backwards as a long narrow segmented stem consisting of nine rectangular joints, and reminding one at first sight of a vertebral column! This part in both fins is cut off by the edge of the stone, so that its actual length and number of segments are not seen. Some small radials are seen attached to the preaxial side of the first two segments,—none on the others, or on the postaxial side of the stem.

The interest of this specimen is extreme, as it is at least capable of bearing the interpretation that we have here a veritable uniserial archipterygium intermediate between the truly biserial one of *Xenacanthus* and the pectoral fin of ordinary sharks. If this interpretation is correct, then, along with *Xenacanthus*, this specimen is a witness against the lateral fold theory of the paired fins at present so popular with anatomists and embryologists. Into that question I shall enter on another occasion; meanwhile so much is clear, that if we have before us the pectoral fin of *Cladodus*—and I do not doubt that we have—the affinity between it and *Chlamydoselachus* is not quite so close as Mr Garman maintains, seeing that in his fish the pectoral fin shows the ordinary arrangement of basal pieces, though the metapterygium has two segments.

What, then, of the *Ctenacanthus* theory? No spine is seen in connection with the East Kilbride *Cladodus;* but, as the body is absent, spines may have been borne by the fish when complete. Again, in the Eskdale *Ctenacanthus* the form and structure of the pectoral fin is not shown; and though I interpreted its one imperfect tooth as "cladodont," I am willing to leave that an open question. It may be *hybodont*, and the hybodont form, with its vertically compressed base, must not be confounded with the cladodont type with its base horizontally flattened and irregularly elliptical or reniform. And in one of the instances which have been advanced to prove the connection of *Cladodus* with *Ctenacanthus*, a

mistake has certainly been made. So far as I have seen them, the teeth which are found associated with the Coal-measure, *Ctenacanthus hybodoides*, Ag., do not belong to *Cladodus mirabilis*, Ag., as has been asserted, but are allied to *Hybodus* in their narrow, compressed non-expanded bases. Mr J. W. Barkas long ago expressed his opinion that most of these so-called Cladodi are in reality "Hybodi" (M. Rev, "Dent. Surgery," Feb. 1874), though he seems to think that the great difference between *Cladodus* and *Hybodus* lies in the former having the outermost denticles larger than the intermediate ones, and consequently admits some of these Coal-measure specimens to the genus *Cladodus*.

Ctenacanthus hybodoides has, therefore, nothing to do with *Cladodus;* and as regards the other species, I rather think that if we knew the creatures to which they belonged, that they would turn out to represent several types possibly very different from each other. But of this I have now no doubt, that the Cladodontidæ, whether they had spines or not, or whatever the shape of their spines, if they had any, constitute a very different family from the Hybodontidæ, and that they were a more archaic group; while the Hybodonts, on the other hand, were closely allied to the Cestraciontidæ.

For if *Tristychius* be a Hybodont, we have now some clue to the structure of an ancient representative of the family

location among the Chimaeroids, as maintained by Professor Hasse.[1] That it is a Hybodont cannot, in my opinion, be doubted.

Orodontidæ, De Koninck.

If the mesozoic genus *Acrodus* is a Hybodont, and its spines are generically indistinguishable from those of *Hybodus*, it is difficult to draw any line between the Hybodontidæ and Orodontidæ.

One of the genera which De Koninck and Mr Davis place in this family must, however, go—namely, *Lophodus* of Romanowski. Romanowski separated from Agassiz's *Helodus* such forms as *didymus*, *lævissimus*, *mammillaris*, as having one or more prominent elevations on the crown, and a well-developed, compressed and vertically striated root; while he considered *H. planus*, which has no such root and no special elevation on its crown, to represent the old genus. Unfortunately both "*Helodus*" *planus* and "*Lophodus*" *didymus* belong to the mouth of the same fish, and that fish is *Psephodus magnus!* Moreover, as I have once remarked, if the old genus *Helodus* were to be divided, surely the characters of the type species *H. simplex* of the Coal-measures ought first to be ascertained and duly considered. Now, a fine series of specimens of *Helodus simplex*, Ag., in the collection of Mr John Ward, F.G.S., Longton, clearly shows that the teeth in this species have the form of "*Lophodus*;" that the entire dentition consisted of teeth generally similar in shape; and that the dorsal fins were armed with spines resembling those of *Pleurodus*. Whatever be the nature of the teeth which Mr J. W. Davis retains in and adds to *Helodus*, there can be no doubt that *H. simplex* must remain the type of Agassiz's genus, and in which also *Chomatodus cinctus*, Ag., ought to be placed, as already indicated both by M'Coy and Davis.

Cochliodontidæ.

The closeness of the alliance between the Cochliodontidæ and Orodontidæ is shown by the fact that the anterior teeth

[1] Natürliches System der Elasmobranchier.

of *Psephodus* and *Cochliodus* are generically indistinguishable from those of *Helodus*.

As seen in *Psephodus*, which is one of the least specialised of the Cochliodontidæ, the posterior teeth lose their deep roots, become flattened, and tend to fuse together into broad inrolled plates. I have a specimen of the broad tooth plate of *Psephodus magnus*, Ag., which, by a groove, is divided longitudinally into two portions, which pretty closely represent not uncommon forms of *Helodus planus*. The grooves on *Poecilodus*, *Deltodus*, etc., also, to my mind, represent the morphological origin of those plates, from the fusion of smaller and narrower separate teeth. *Pleurodus* is a well-known form in which each plate is due to the union, back to front, of a row of helodont teeth, whose lateral extremities still tend to project free on each side.

That the cochliodonts all possessed dorsal spines seems highly probable. Those of *Pleurodus* have been described by Hancock and Atthey.

Petalodontidæ.

If we take *Ctenoptychius apicalis*, Ag., as the type of its genus, I must own that I fail to see any valid reason for separating *Ctenopetalus* from it; and even *Petalodus* is scarcely

stone, Beith (Carboniferous Limestone series), which was apparently undescribed. It is small, flattened, and broadly triangular, the anterior margin being 1 inch in length, the posterior 1⅜ inches, the base ¾ inch in breadth. The apex ends in a sharp spike; and just below this, on the posterior margin, are two others, directed backwards. Externally the surface is ornamented with distinct furrows, running parallel to the anterior and posterior margins, consequently tending to radiate from the apex towards the base, and giving the surface a feebly ribbed appearance. On these ribs are small tubercles, irregularly placed towards the apex, then becoming arranged in lines which proceed obliquely, or with a slight sigmoid curvature, across the surface from behind, downwards and forwards. I have seen other specimens of the same spine from the Carboniferous Limestone "bone-bed" at Abden, Fifeshire, collected by Messrs W. Anderson and W. Tait Kinnear, which show that the walls were thin, and the spine consequently extremely hollow. In these specimens the external ribbing is also feebler, and the tubercles more thickly placed.

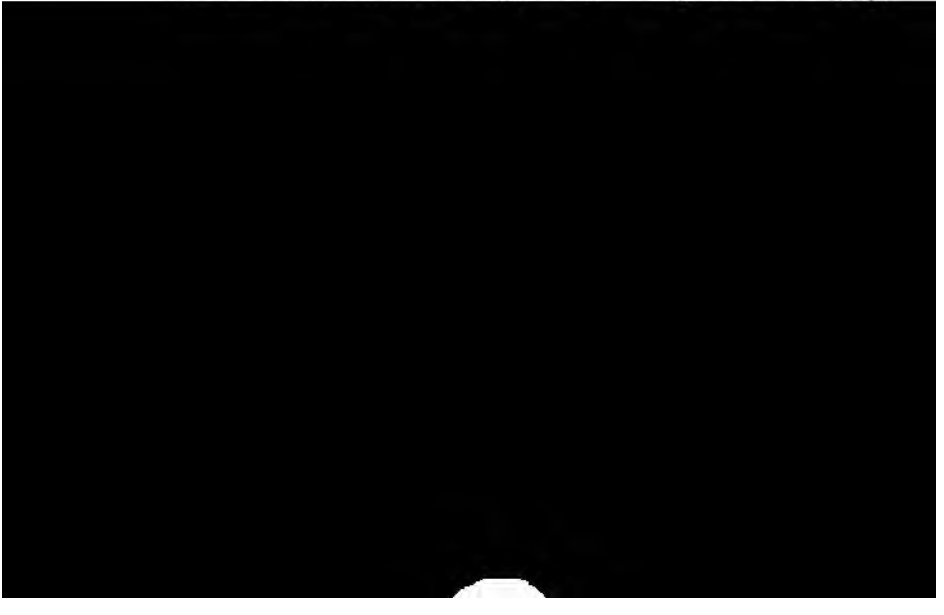
In their general configuration, and in the nature of their surface ornament, the resemblance of this spine to *Oracanthus* is obvious, although the posterior area is not so sharply defined, and though neither of the sides is notched or sinuated on the lower margin as is, so far as my observation goes, usually the case in the genus mentioned. It has, perhaps, still thinner walls than the typical *Oracanthi*, and might on that account be referred to St John and Worthen's genus *Pnigeacanthus*; but the generic distinction of this from *Oracanthus* is doubtful. No *Oracanthus* has hitherto been described with spikelets at the apex; but as the apices are more or less worn, a ready explanation of their absence is obtained. I, therefore, designate this spine *Oracanthus armigerus*, with the remark that if it be not a true *Oracanthus*, it is an excessively closely allied form.

Mr Davis recognises that the spines of *Oracanthus* existed in pairs, and are not bilaterally symmetrical, having one side larger than the other; but when he refers them to the "posterior termination of the body," hints at removing the genus

to the "placodermic ganoids," and figures a whole series of really undeterminable fragments as bones of the head of this supposed Placoderm, we can hardly follow him. I have carefully gone over all the specimens in the British Museum which he has figured as "upper jaw," "central bone of cranium," etc., and can find no evidence for such determinations. I have also examined microscopic sections of *Oracanthus*, and find that they consist of selachian dentine; and we may also appeal to the obvious resemblance which the spines of *Oracanthus* bear to the thin-walled triangular appendages often found associated with *Gyracanthus*, and which, though not "carpal bones," as Messrs Hancock and Atthey imagined, are unquestionably selachian in their nature.

The writer of a review of Mr Davis's work, which appeared in the "Geological Magazine" for November 1883, does not believe that the *Oracanthi* formed the posterior extremity of the body of a Placodermic ganoid, but that "it seems probable that they may have occupied a lateral position on the head of these old Elasmobranch fishes." And if I am right in my generic determination of *Oracanthus armigerus*, ample corroboration of this view has now turned up.

In the Museum of Science and Art, Edinburgh, there is a specimen from the Eskdale beds, showing the head of a small selachian, crushed vertically, along with part of the body,



never show more than two cones, a large one and one small lateral one, which is absent in some specimens, ought to be included in a new genus distinct from *Cladodus*. I therefore propose for this form the name *Dicentrodus*, and venture to express an opinion that it will turn out to be more allied to *Diplodus* than to *Cladodus*.

XXXV. *Further Notes on Carboniferous* Selachii. By Dr R. H. Traquair, F.R.S., F.G.S.

(Read 15th February 1888. Appeared also in the *Geological Magazine* for March 1888.)

Anodontacanthus and Pleuracanthus.

In 1881[1] Mr J. W. Davis proposed the genus *Anodontacanthus* for certain straight spines resembling *Pleuracanthus*, but differing in the absence of the two rows of denticles. Three species are included:—*A. acutus* and *obtusus*, from the Coal-measures of Yorkshire, and *A. fastigiatus*, from the Blackband Ironstone of Carboniferons Limestone age at Loanhead, near Edinburgh.

I offer no criticisms on the two Yorkshire species, nor have I seen the type of the Midlothian *A. fastigiatus*. In the large collection of spines which I have from Loanhead, there are, however, many which I refer without doubt to the last-named species. Now, although some of these are smooth and without denticles, others show in all stages of apparent wearing away undoubted stumps of denticles, whereby the species *fastigiatus* falls into *Pleuracanthus*, as it at present stands.

It is to be noted that a large number of the spines found in this Ironstone (Loanhead and Borough Lee, No. 2) are singularly worn or eroded all over, as if they had been long exposed to the action of agencies, chemical or mechanical, tending to destroy the surface. I have seen a spine of *Gyracanthus* from that bed having every vestige of the surface ornament, so elaborate in that genus, removed, and I had to examine it microscopically before I felt absolutely sure of its

[1] *Quart. Journ. Geol. Soc.*, vol. xxvii., p. 427.

genus. Other *Gyracanthi*, etc., are found in every stage of "polishing off." But this phenomenon is by no means peculiar to the spines and other fish remains from Loanhead; it is tolerably frequent elsewhere, and is apt to lead into error those who have not yet learned to take it into account. *Pleuracanthus erectus*, Davis (*Quart. Journ. Geol. Soc.*, vol. xxxvi., p. 326), is to my mind nothing but an eroded specimen of *Pl. lævissimus*, Ag., the "very blunt-pointed" character of the denticles being thus amply accounted for; and I have a specimen of *Pl. elegans*, Traq., from Loanhead, which shows precisely the same condition. *Pl. Wardi*, Davis (*ib.*, p. 334), probably owes the bluntness of its denticles to the same cause. And I feel pretty well persuaded that T. Stock's *Lophacanthus Taylori* (*Ann. and Mag. Nat. Hist.*, 5th ser., vol. v., p. 217) is nothing but a worn specimen of *Pleuracanthus* (*Orthacanthus*) *cylindricus*, Ag.

PRISTODUS FALCATUS, Davis (*ex* Agassiz MS.).

Mr Davis, in his large work on the Carboniferous Limestone Fishes of Great Britain, in describing the remarkable tooth, to which Agassiz had given the name *Pristodus falcatus*, makes no reference whatever to the fact that a closely allied species had been already, in 1875, figured and described

This statement as to affinities by Mr R. Etheridge, jun., cannot be called in question by any one who has studied the structure of the teeth and jaws of *Diodon;* nevertheless, six years afterwards, we find Mr J. W. Davis, at the British Association in 1881, naming this tooth *Diodontopsodus*, and apparently going back on the idea of its Gymnodont affinities: "In *Diodontopsodus* the teeth are extremely like those of the existing fish *Diodon*" ("Proc. Brit. Assoc., 1881," Trans. Sect., p. 646). And in his large work on the "Carboniferous Limestone Fishes" he seems still unable to free himself from this idea. At p. 521 he says—"In searching for the zoological relationship of *Pristodus*, a striking and most peculiar resemblance is at once observed between it and some of the Gymnodont group of the Plectognath group of fishes at present existing. . . . In many respects the fossil teeth from the Mountain Limestone of Yorkshire bear considerable resemblance to those of *Diodon*. In the general form of the palatal interior, combined with the semi-circular external, trenchant edge of the tooth, the two are almost identical. . . . A comparison of the recent and fossil teeth, however, leads to a natural inference of relationship in some degree, however remote. Evidence is entirely wanting as to the anatomical structure of *Pristodus*, and I do not wish to lead to the inference that it was more nearly related than is warranted by the peculiar similarity of the teeth." I very much fear, however, that the "peculiar similarity of the teeth" is a very deceptive one after all.

But although *Pristodus* cannot have had the remotest *affinity* with *Diodon*, it is quite an open question as to whether there may not have been some *analogy* in the form of the jaws, a couple of these peculiar tooth-plates, one above and one below, forming the whole of the armature of the mouth. Rather against this view, however, is the fact that the height of the crown in these teeth is extremely variable, as may be well seen in the extensive series of *P. falcatus* in the British Museum, and that in some the apex is more acute, or tending to be mucronate, than in others.

Mr J. W. Davis's *Pristicladodus concinnus* seems to me to

be nothing more or less than a crushed specimen of a species of *Pristodus*, with a more than usually mucronate apex.[1]

PRISTICLADODUS, M'Coy.

There can be no doubt that the specimen from Armagh, in the British Museum, to which Mr J. W. Davis has given the name of *Carcharopsis Colci*, is nothing else than a specimen of *Pristicladodus dentatus*, M'Coy, with the base broken off.

CHONDRENCHELYS PROBLEMATICA, n.gen. & sp.

Among the fishes from the Eskdale beds, obtained from Mr Damon for the Edinburgh Museum, is one whose nature is still more problematical than that of *Tarrasius*, which it somewhat resembles in external shape. Two specimens in the Edinburgh Museum have the head and tail preserved up to near the termination of the latter, and of these the lengths are, respectively, 4¾ and 7 inches. The shape of the body is singularly elongated and eel-like, the head being small, less than ⅛ of the total length, while a long, low, continuous dorsal fin runs along the back from not far behind the head to the end of the slender pointed tail.

In the larger of these two specimens no structure can be

shoulder-girdle, or coraco-scapular arch, whose direction is obliquely downwards and forwards. Careful examination reveals no composition out of distinct membrane-bones; on the other hand, its substance has an unmistakably granular aspect suggestive of calcified cartilage. No trace of paired fins, pectoral or ventral, is visible.

Commencing at the head, and passing back under the aforesaid shoulder-girdle to the extremity of the tail, is a well-marked vertebral column. Here the axis consists of undoubted centra, which are rather higher than long. They are crushed and flattened laterally; but on careful examination of a most instructive fragment in the collection of the Geological Survey of Scotland, they can clearly be made out to have had the configuration of hollow rings, through which a scarcely constricted notochord must have passed. Appended to the dorsal aspect of this chain of centra is a series of bodies representing the neural arches and spines. Each of these is short, slender, and rod-like, bifurcating below and pointed above, and there seems to be one for each centrum. They are not composed of ordinary bone, but of small granules placed end to end like a string of beads; and that they had not the rigidity of bone is seen from the flexuosities which they often present in their contour. Commencing almost immediately behind the shoulder-girdle, and appended to the neural spines above, is a second series of rod-like bodies representing fin-rays or radials, of which there are three or four to each neural spine; they are more slender than the latter, but have the same granular structure. They gradually increase in length towards the posterior third of the body, whence they again fall away towards the end of the tail. The abdominal region extends for $1\frac{3}{8}$ inches behind the head. No ribs are visible, the termination of the abdomen being marked by the commencement of a series of hæmal elements quite similar in configuration and structure to the neural ones above, and these now extend to the extremity of the tail. No fin-rays are seen on the ventral aspect of the skeleton, nor have I seen any trace of any dermal hard parts.

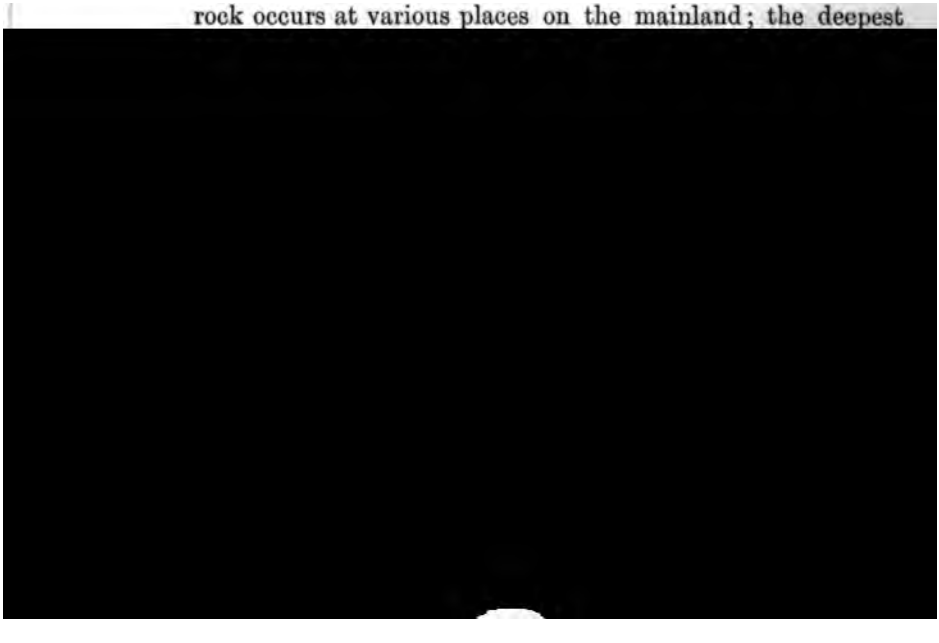
This is, indeed, one of the strangest fishes as yet yielded

by these Eskdale deposits, which have proved so rich in palæichthyological treasures. We are not aware of any ganoid, recent or fossil, whose body is entirely destitute of dermal hard parts, for even the all but naked *Polyodon* of the present day, and also the Carboniferous *Phanerosteon* have still a few scales on some part of their surface. It seems also scarcely probable that the apparent absence of membrane bones from the head and shoulder-girdle is entirely due to deficient preservation; and the granular structure of the vertebral apophyses and radials is not paralleled, so far as I know, in any Ganoid. It certainly is not an ordinary Ganoid, nor is it an Acanthodian. On the other hand, its affinity to the *Selachii* seems to be indicated by the position of the shoulder-girdle, and by the granular calcification of the vertebral apophyses and radials, and probably also of the head and shoulder-girdle. If it be a Selachian, it is certainly one of a very primitive and at the same time aberrant type. In its long dorsal fin it resembles *Xenacanthus;* but there is no cephalic spine, apparently no paired fins (though this may, indeed, be due to defective preservation), the vertebral centra are more developed, and the two rows of dorsal interspinous cartilages, or "Flossenträger," described by Kner in that genus, seem to be absent. It is certainly a new, as well as a most interesting form, for which I accordingly

and Fernando Noronha lie Booby Island, St Michael's Mount, and Egg Island. These form a kind of chain running north-east, while to the north-west are Platform Island, or San Jose, and two rocks. The other islands are all very small, and are known as Moro da Villa, a peninsula at low water, and The Twins, both lying off the north-west coast; to the south are Les Clochers, which bear a curious resemblance to a praying monk from some points of view, and several other rocks. The coast-line of the main island is considerably indented, the principal inlets being, on the north-west coast, Water Bay, above which the principal village is situated, and Portuguese Bay. On the south coast is Leão Bay, circular and almost landlocked.

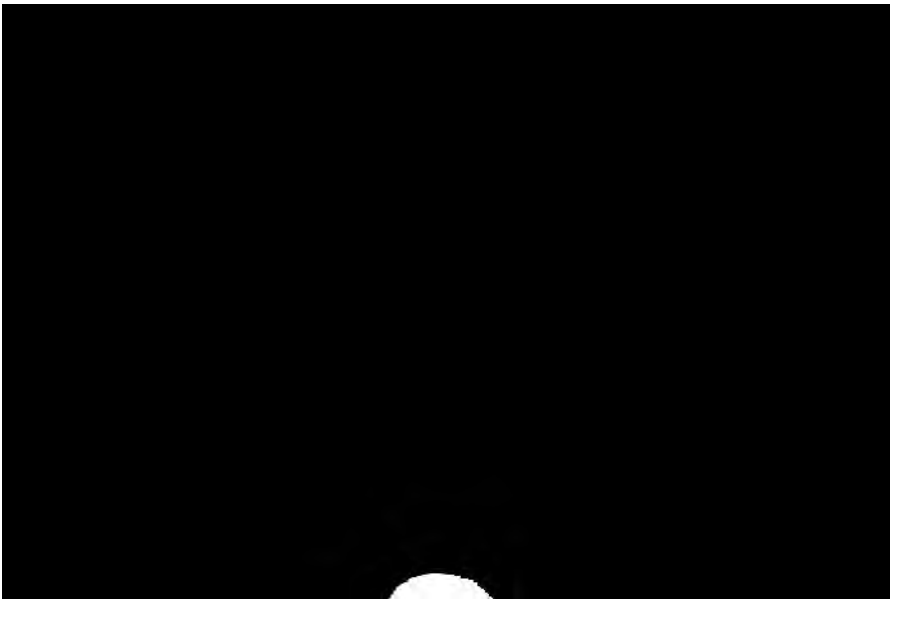
The geology of the group, so far as we could make it out, is as follows:—The central part of the main island, containing several steep conical hills, consists of phonolite, while both ends are of basalt. The western part seems to have a regular trap formation. There is a long gradual slope up from the plain, just to the west of the central hills, ending in a crest, from which there is a steep slope down on the other side. From its base another slope rises, not so long as the other, and ends in another crest with a steep descent beyond; and, still further on, there is a third repetition of the same feature. The slope down from the last ends in a narrow neck of land, connecting a terminal peninsula with the mainland. In this neck is the natural opening known as the Hole in the Wall. The configuration of the east end of the island is much more irregular than the part already described. A range of hills of black basalt rises abruptly from the coast, and comprises four or five distinct peaks. To the north of these, and separated from them by a valley, is a low, rounded ridge, forming the backbone of the north-eastern point; and a third eminence, also rounded in form, occupies the north-western portion of this region. The central hills comprise The Peaks, rising close to the north shore, and two small conical hills; otherwise this part of the island is level. On the south shore are two elevations, Tangle Hill and Look Out Hill. The former exhibits two pinnacles, and reaches the greatest height of any of the mountains, with the exception

of The Peak. Look Out Hill, of conical form, obtains its name from a hut on the summit, which is used as a watch-house. Immediately north of the base of Tangle Rock is a smaller rounded eminence, and lastly, a little hill with loose masses of phonolite on its summit, lies not far north of Leão Bay. Outcrops of phonolite occur on all those hills, but the character of the rocks underlying the deep red vegetable soil covering the level ground between them is difficult to determine. The western coast is lined with cliffs, or, at least, very steep rugged slopes, but there is generally a beach beneath them, at any rate at low water. At this season of the year a fine sand, composed almost entirely of shell fragments with a few grains of hornblende, covers the beach all along the north-west coast from Portuguese Bay eastwards, as well as various other points on both the southern and eastern shores. Just south of the north-east point, and also at Sambaquilbaba on the north-west coast—where there is a small settlement—immediately inland from Leão Bay, the sand is blown into dunes, which, in the two last-mentioned places, are planted with cocoa-nut palms. In the north-east it shows traces of incipient consolidation in the shape of waved and branching streaks of agglutinated sand traversing the mass. A calcareous sand rock occurs at various places on the mainland; the deepest



a reef of rock, composed of sand, coral, tubiculous lamellibranchiata, and calcareous algæ, is seen, at low water, almost completely surrounding the island. It is exceedingly rugged and full of holes, very like some presented in the sand rock into which it passes, without any line of demarcation whatever, in a number of different places. Egg Island is united to the mainland by the reef, so as to be accessible at low water, as is Platform Island, but, in the latter case, the reef is replaced by basaltic boulders. It would thus appear that the sand rock is rather raised reef than consolidated dunes. A very friable volcanic conglomerate occurs on the seaward slopes of the East Hills, and also on the declivities above the south coast near the west end, and nearly opposite on the north-west side, and on the slope toward the Lapate. Something very similar appears in the bed of a stream in the central region. The faces of the shore cliffs in the western part of the mainland, and also in Rat Island, show bands of rock something between clay and conglomerate, the ground mass being highly vesicular, but containing a number of round pieces of solid basalt. This sometimes gives the cliffs a terraced form, and sometimes, when seen from a distance, makes them appear stratified. Besides the phonolite in the centre of the island various bosses of that rock crop up through the basalt. It appears thus at the base of the East Hills, and also on the north-west coast on both sides of Water Bay. Moro da Villa is phonolite, as is the point of land immediately adjacent to it, and the high bluff on which the fort stands, on the east side of the bay. Another phonolitic boss occurs between the fort and the north-east point, and, on the south coast, a small hill, known as Moro Branco from its white colour, is composed of the same rock. Of the outlying islands St Michael's Mount, Les Clochers, and the other rocks along the south coast are phonolite, but the Twins, to the north, and Platform and Rat Islands are of basalt. Wherever the phonolite and basalt meet, both rocks show traces of alteration, the former becoming quite dull and of a pale grey, almost white, while dykes of the latter, of which there are often a number traversing the phonolite at such places, contain abundant crystals of augite, but, so far

as we could see, no olivine. About the north-east corner of the island, among the basalt boulders which cover the beach, there are a great number of masses of olivine crystals, some of them measuring three inches in diameter. A curious pale brown, cherty-looking mineral frequently occurs in the form of veins among the phonolite. The phonolite probably indicates the plugs of the orifices from which the most ancient eruptions took place, as the columns, into which it is everywhere cleft, usually lie inclined at a low angle, or completely horizontal. It is really not at all of a slaty nature, as some of the previous accounts indicated, but distinctly columnar. The basalt occurs principally in sheets with the main joints vertical. In some places, especially towards the north-east, it shows the "cannon ball" method of weathering very well, and in some others, as the East Hills and the place known as Pedras Pretas, or Black Stones, in the south-west, the jointing is quite irregular, and the rock separates into large, angular, scarcely weathered fragments, which make a perfect desert of black stones, with cavities between them which go down to an astonishing depth. The small patches of tuff are, I imagine, only the remains of a much larger quantity which must have once enveloped the phonolitic hills to their summits, and through which the basalt subsequently burst. On Rat Island, as



the attempt, a result quite as common as success. The most remarkable of the trees are, first, the *Ficus Noronhæ*. Of it, the finest specimens are in the Governor's garden behind the Præsidio, and show a complicated system of interlacing trunks, and numberless bunches of aerial roots hanging from the branches. The leaves are large, deep green, glossy, ovate, and obtusely pointed. On one occasion we came upon one with ripe figs, deep red in colour, of sweetish taste, but of no great use as food; they were about an inch in diameter, and almost spherical in form. The next tree deserving notice is that known to the inhabitants as *Buna*—the *Laurelled bara* of Webster—so much dreaded for its milky juice, which is said to blister the skin. We got it all over our hands repeatedly without feeling any effect whatever; but on two occasions Mr Lea got some in his eye, which gave him much pain for some hours, but did no further harm. It is very hot to the taste. Its baneful effects seem to be over-rated; a number of cattle and horses were, however, pointed out to us with patches of hair removed, which the people attributed to the action of this juice. The stems of the plant are rather straight, the leaves glossy, green, leathery, ovate, and lanceolate. We had great trouble in finding the flowers, but at length succeeded in getting some from trees which were almost bare of leaves; so it would appear that the flowers come out at one time, and the leaves at another. The flowers are small, green in colour, and of very simple construction. The males, which occupy the upper part of the spike, consist of two stamens; and the females, which are situated at the base, are only an ovary with a thoroughly euphorbiaceous aspect. We could not find any fruit; we seemed to have arrived at the wrong time of the year for this purpose. Next may be mentioned the Mulungu, probably the *Erythrina exaltata* of Webster, and also, probably, the same as that described by Mosely in the "Challenger" Reports as an euphorbiaceous plant, with rounded, bluish-green leaves and thorns. Webster described it as the tallest tree on the island; those we saw, however, were all small, the larger ones having been cut down for the reason already mentioned. It is said that a jiungada made

of this wood becomes water-logged, and sinks in three days. We came on one specimen about twenty feet high; it was in full flower, and proved to be leguminous. The flowers are provided with a large orange vexillum, small green alæ veined with red, and long crimson stamens; the leaves are broadly ovate, rather dull-green in colour, and have a hairy lower surface. The whole tree is thorny; the fruit is a long pod. Mr Lea heroically scrambled up after the flowers, despite the thorns, and got some down in triumph. There are no other trees of any considerable size, except cocoa-nut palms and a few other cultivated forms; but there are large numbers of shrubs. Among them is a *Begonia*, with fine large flowers, white mottled with pink, and just two spots of yellow on one lip; there are also some shrubby capers, which flower very shyly, so that it is very difficult to get them open. We observed a shrub, with leaves dark-green and glossy above and whitish beneath, having inconspicuous brown flowers, probably euphorbiaceous, and also belonging to the same order, the *Jatropha gossypifolia* of Webster, which may attain the size of a tree, but we seldom saw any larger than a shrub. It has palmately-lobed, smooth, green leaves, and bunches of flowers with a pale yellow perianth, touched with crimson on the outside. A first cousin of this plant, *Jatropha urens*, only reached the condition of a tall

and usually obtuse, commonly forming a bunch immediately beneath the base of the flower stem. The endemic cactus, *Cereus insularis*, is everywhere very abundant. Its stems are cylindrical and fluted, beset all over with long and sharp prickles. This plant attains a height of four or five feet. The flowers open at night, and close in the morning. By bringing home buds we got them to blow under our observation, and succeeded in getting a fine view of the completely opened flower, which is large, milk-white, and sweetly scented. We also found a quantity of the ripe fruit—a species of pear, of a bright crimson colour, with white bloom. A cross section showed the centre to consist of a white substance, enclosing dark-brown seeds. It had a pleasant, sweetish taste, except the outer, crimson part, which is bitter and nasty. The only other endemic plant is the *Gonolobus micranthus;* it has a twining stem, with small, greenish-brown flowers, and large, dry fruit. The seeds are dark-brown, each having a white pappus; the leaves are cordate, somewhat rounded at the apex. There are a number of Convolvulaceæ, *Ipomœa pescaprœ*, with large, purple-crimson flowers, red stems, and broadly ovate, leathery leaves, trailed to immense lengths over the sand dunes and the beach above high water mark. Another *Ipomœa*, with white flowers, and known as *Salsa d'apraia*, grew in rocky places; it blooms by night, its flowers being always withered in the morning. The small potato—or, as they call it here, *batata*—is another species of convolvulus, almost as abundant as the two just mentioned. There was also another form, white in colour, and one of smaller size, varying in shade from pale lilac to white. The wild pumpkin (*Momordica charantia*) was universally abundant, almost smothering the trees and bushes in some spots. The yellow flowers are small; and the fruit, a little orange pumpkin, about three inches long, covered with tubercles. When ripe, it splits into three valves, which curl up and display brilliant scarlet seeds within. The leaves are of a vivid green, deeply lobed. This plant is also abundant at Pernambuco. Melons and pumpkins, of various kinds, are cultivated on stony grounds in all parts of the island, and do exceedingly well. A great number of Legu-

minosæ was observed; two or three cassias were abundant as cultivation weeds; as were also a purple flowering *Phaseolus*, and a white flowering bean. Another species of the latter, with large pink flowers, passing into purple as they faded, grew on the seaward slopes, and bore large pods containing enormous beans very good to eat. We also observed a number of small vetch-like forms. One, with whitish leaves and small pink flowers, had a root, which, when bruised and put in a rock pool, would kill all the fish in a few minutes; there were also numbers of acacias, both cultivated and wild. Three or four euphorbs, besides those already noted, small herbs, and two nettles, may be mentioned. Mallows were numerous; one little form, with pale yellow flowers and dark brown centre, grew abundantly all over the sand dunes, where it contrasted beautifully with the crimson *Ipomœa*. A large *Hibiscus*, with yellow flowers and pods which used to be boiled with beef for the table, grew freely. A very abundant weed was a pale lilac composite, like an *Ageratum;* there were but few other composites. Of grasses no great variety exists, and most of them are plants of wide distribution. We got one fern, and also a small moss with fructification, a fact of special interest, as vascular cryptogams have hitherto been supposed to be absent from the island. The shore was exceedingly bare of algæ; we saw nothing like

the first mentioned small bird, one being unfinished; the other contained at least one egg, white, with purple spots. It was so placed, however, as only to be secured by cutting down the branch that held it, so that the egg, or eggs, were broken by the fall. It was well built of dried grass and the pappi of *Convolvulus*, lined with a few sea-bird's feathers. There was a nest of the sylvia on a branch of the Mulungu tree from which we got the flowers, but we were unable to secure it. We got a good series of the skins of all these birds. A few waders frequented the shores, one like a curlew, another brown and white bearing some resemblance to a plover, and the third looked like a sandpiper. They were all so shy that it was found impossible to secure any specimens. Evidently they are not endemic, as their number is too small to maintain the species. Sea birds were abundant, including frigate and tropic birds, noddies—one, white in colour, called here "Viuva Branca," or "the white widow"—boobies, and one or two other less common forms. The reptiles are, first, an endemic skunk, *Euprepes punctatus*, brown in colour with spots of a brighter tint, with a fine iridescence on its scales. Large specimens are quite ten inches long. A gecko is abundant in the houses and on banana stems; and a small *Amphisbæna* is very frequently found under stones. Insect life is exceedingly poor. There are large numbers of immense yellow-bodied dragon-flies, and a few with red bodies. All the streams and pools are full of their larvæ. The black cricket of the island is in thousands in the fields, chirping on every side; it is not a mole cricket as has been stated in several of the accounts of Fernando Noronha. Two species of green locusts are very abundant, and we got a grey one, of great size, in the woods; a yellow-legged grasshopper swarmed in the herbage, but was difficult to catch. A very fine red bug was seen running about in the thickets. Beetles are few, small, and dull in colour; but one *Scarabæus*, found in the woods to the west, was large. But we appeared to have arrived at the wrong season, as we only found fragments of the adult insect. One day, however, I succeeded in finding a few larvæ under some stones—huge white grubs, like great cockchafer larvæ. We saw enormous

numbers of brown wasps; their nests, which consist of paper webs without any external protection, hung from the branches of every tree. A large yellow and black species burrowed in the sand dunes. There were two small black bees, and others of various colours. Ants swarmed everywhere, *Myrmeca domestica* being particularly abundant. Dipteræ were represented by legions of the common house fly, lots of bluebottles, some mosquitos, two small *Muscæ* with shining bodies, one green and the other blue, and some others, but not of large size. We only secured one butterfly, not unlike our own common blue, but smaller and less brightly coloured. About a dozen species of moths were collected; the most abundant, during daylight, were a dull brown variety, and another, smaller, with satin-like white wings having a broad dark brown border; one nocturnal species was caught, and some of a small emerald-coloured variety. This catalogue is simply miserable compared with that of Pernambuco, and we were much disappointed with this part of our collection.

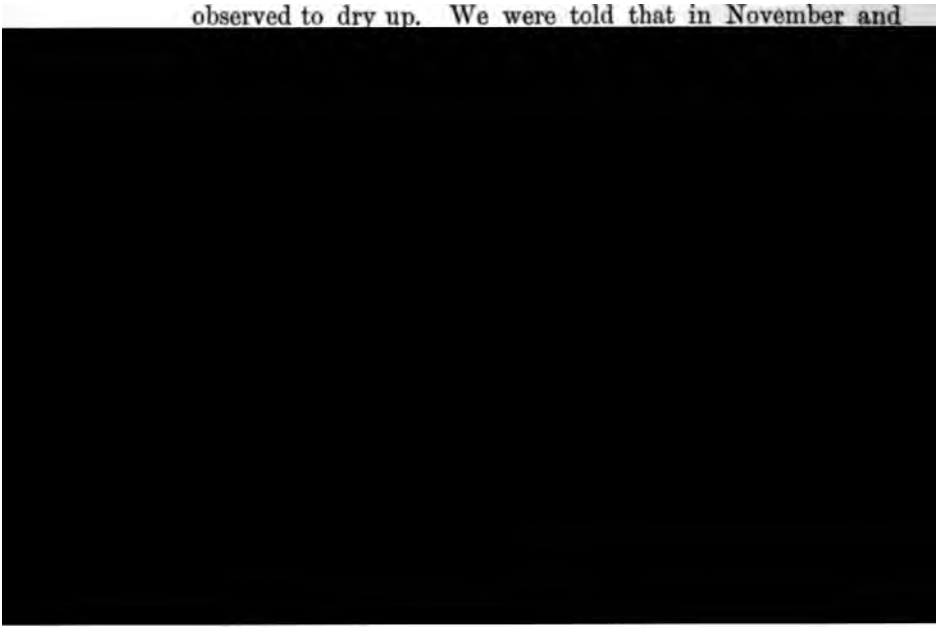
In fresh water we got two crustacea; one, a small *Gammarus*-like amphipod, occurred in the streams; the other, an ostracode, about the size of a split pea, was abundant everywhere. In a lake, which lies in the south-west part of the island, are millions of ostracodes, but no other animal life

several species of most brilliant colours; one is bright yellow with black transverse stripes; another is bright blue on the head and fore-part of the back, and orange towards the tail; another, again, is bright scarlet; another, olive-green with white longitudinal stripes. A curious little fish, having a very short, deep, compressed body and a somewhat elongated snout, was to be seen in company with those already mentioned. We observed several larger fish of a similar character; these live in deep water. One is a huge brute, about four feet long and very thick in proportion, with an immense head. Bonitos and others of the mackerel tribe are caught here, and a beautiful, large, red fish, a species of pike, as well as some others. Numerous shoals of sardines haunt the edge of the sea. On the shore a fine black and yellow *Muræna* is very abundant, and a small gar-fish with a spike at the end of its lower jaw is far from rare. A species of sting ray, of immense size, and plenty of sharks may also be mentioned. Our guide one day caught four or five large red plectognathous fish; we also secured a gurnard with the pectoral fins immensely enlarged like the flying variety of the Mediterranean. Two or three times we saw turtle swimming about, and once a small dolphin was killed.

Other forms of marine life are, as a rule, scanty. Small shrimps and *Mysis*-like crustacea were hardly to be seen. There are, however, a few small prawns, and a burrowing lobster, with one chela much enlarged and curiously shaped, a large *Palinurus*, and a small green *Squilla*. Crabs are very abundant, including a white species which burrows in the sand, a purple land variety living up in the hills, an exceedingly active green shore crab, having a small body, and long flattened legs which enable him to run among the rocks near high-water mark with great quickness. Other varieties live lower down; and one, a funny whitish speckled thing, something between a crab and a lobster, runs at a great rate in the back wash of the waves on sandy beaches. There are a few small amphipoda. The worms are very poor; one is rather large, pinkish or greenish in colour, with tufted red gills above each parapodium, and bunches of white silky-looking setæ which stick into the

skin and cause irritation. It was remarkable to see how, when this creature was touched, it bristled up like a hedgehog. Among the Sedentaria, a small form, with tubes of shell fragments, was found adhering to the under surfaces of stones; a fine *Sabella* with dark red gill plumes, which inhabited the mud tube attached to the under side of the reef shelves; a most magnificent *Serpula*, with a curved spine over the aperture of its calcareous tube and of gorgeous colour, was also observed. The Mollusca were not numerous, except limpets, of which we saw several kinds. Many shells belonging to this order we found to be tenanted by hermit crabs. A species of oyster was found firmly adhering to the reef by a single valve. A small *Aplysia* was abundant, as was also a species of octopus. Asteroideæ were entirely absent. There are many sponges; their skeletons, thrown up on the beaches, would frequently do very well for bath use.

In regard to climate, we found the temperature exceedingly equable, and we had an almost constant breeze day and night. In the end of August and beginning of September many very heavy showers fell, but later, these got much less frequent, and the place began to get rather dessicated; and the herbage which, on our arrival, had been of a brilliant green, was observed to dry up. We were told that in November and



plete specimens of *Eurypterus*, *Slimonia*, *Stylonurus*, and *Pterygotus* have been obtained and carefully studied. It is not so, however, with the Eurypterid remains interred in our carboniferous rocks, for though minute fragments of their coatings, showing the characteristic sculpturing, have been brought to light from almost every horizon of that formation in Scotland, and more especially from the beds which represent its old land surfaces, yet the hitherto described specimens may almost be counted on the fingers of one hand.[1] It is therefore highly gratifying to obtain a specimen of the cephalo-thoracic shield of an Eurypterid, in an almost perfect state of preservation, from the highest Coal-measures of England. For the opportunity of studying the specimen, and bringing the results before this Society, I am indebted to my friend Robert Kidston, who has so ably worked out the flora of the Radstock coalfield.

Description of Specimen.

The cephalo-thoracic shield, or carapace, is semi-ovoid, the posterior margin along which it was attached to the trunk being arcuate. The carapace is arched and tumid, and diversified by several areas of elevation and depression. A mesial depression passes from the posterior to near the anterior margin, and two shorter depressions run more or less parallel to it, one on each side, separating the cheeks from two raised areas on the back. Two further depressions cross the path of these obliquely, and pass inwards from the lateral margins, a little in advance of the postero-lateral angles, and meet in the median groove, near the posterior margin. Nearly half-way from each end of the median groove rises a small elongated eminence, bearing the simple larval eyes or ocelli, which are oval and about 1 mm. in longest diameter, and separated from each other by an

[1] Mr James Bennie, who has for several years been continuing his researches into the old land surfaces of the carboniferous strata of Scotland, mainly with the purpose of searching for Lycopodraceous spores, finds fragments of Eurypterus and Scorpion in more or less profusion in many coal seams and "dirt-beds," especially from the lower carboniferous strata, which he has more particularly studied.

extremely narrow isthmus of sculptured test.[1] The lateral or compound eyes rise out of the lateral grooves, one on each side, a little in advance of the ocelli. They are placed on elevations, which rise more steeply along their outer than on their inner side. The corneal portion of each eye is reniform, with the convex side outwards, and arranged so as to look forwards, outwards, and upwards. It is bounded by folds of test which resemble eyelids. The cornea is divided into numerous minute facets, arranged in oblique lines, ranging forwards and downwards from the upper to the lower eyelid. Along each line the facets number from 12 to 14 to the mm., according to the amount of distortion the specimen has undergone during fossilization.

The test is folded downwards and inwards for a short distance along the posterior margin. Along the three other sides it is folded in to a much greater extent, and can be seen to reach inwards to almost beneath the compound eyes. Folds of this flange are seen to commence near the antero-lateral margins on each side, and to pass forward and slightly diverge from the marginal lines. They evidently meet in the middle line, though the dorsal portion of the test preserved in the fossil obscures that part of the flange. This doubtless corresponds to the fold which simulates the horse-shoe on the under side of the carapace of Limulus.

is more coarsely sculptured than the depression out of which it rises. The sculpturing is continued up to the edge of the faceted cornea of the compound eyes. The other oblique grooves are also finely sculptured. Near the lateral margin, a little in advance of the grooves, the squames are highly elongated and imbricating, so as to resemble the feathers of a bird's wing.

Near the anterior and antero-lateral margins the squames become less and less convex, and run together so as to form sinuous lines, which interosculate with each other, and bend round gradually as they approach the lateral margins, so as to impinge upon them at very acute angles. As the intermediate spaces between the lines are pitted and punctate, the whole ornamentation in such places is almost identical with that which occurs in a similar situation, and is characteristic of the family of Asaphidæ, among the trilobites. The flange, or that portion of the carapace which is bent inwards to form the under surface, is also sculptured. Between the margin and the fold above mentioned the squames are minute and pointed, and sparsely set. Within this they are large, and run together to form inosculating sinuous lines. Perhaps the most curious feature of the case is, that while the convexity of the squames on the dorsal surface is always directed backwards, on these flanges the opposite is the case, for they point outwards and forwards, as if the flange were in reality a portion of the carapace, which had not long in the life history of the Eurypterids been folded over from the dorsal to the ventral side. This seems to have an important bearing upon the position of the lateral eyes in the different genera of the family. Those having the eyes marginal may be considered as having this folding over carried to a greater extent than those in which the eyes still remain upon the dorsal surface.

In the *Geological Magazine* for November 1887, Dr Henry Woodward has described a Lower Carboniferous Eurypterid, from Langholm, Dumfriesshire, under the name of *Eurypterus scabrosus*.[1] It is evident from the form, that the above-described carapace belonged to a species nearly allied to it.

[1] Geol. Mag., Dec. 3, vol. iv., No. 11, pp. 481-484.

Dr Woodward thinks that the structure proves that *E. scabrosus* had been an aquatic animal. Judging from the figure which accompanies his paper, there seems to be no organ displayed which would warrant this conjecture. The appendage on the right side, marked 2 in the figure, is very different from those succeeding it, and is in all probability, as suggested by Professor Huxley,[1] a portion of a chelate limb. It is stouter than the others, and the second visible joint bears a row of tubercles, which strongly recalls those borne on the third joint of the chelate palpus in scorpions, with which joint this is in all likelihood homologous. Dr Woodward is therefore probably in the right in looking upon it as one of the second pair of appendages. From the study of the older Eurypterids, I am in a position to show that *Eurypterus scorpioides, Slimonia acuminata,* as well as *Pterygotus Anglicus* and *P. bilobus,* had each a pair of chelate appendages, but these were the homologues of the chelicerœ, or the first pair of appendages in scorpions and Limulus, and the phalangids and the falces of spiders. Like the homologous organs in those animals, these bore no gnathites at their bases, a fact long ago pointed out by Woodward in the case of the nippers of *Pterygotus bilobus* and *P. Anglicus.*[2]

In the above-mentioned older genera and species the

Slimonia acuminata, which vary according with the differences observed in the opercular or genital plates. To return to Woodward's figure of *E. scabrosus*, the limbs marked 3 and 4 are unlike those of any described *Eurypterus*. Limb 4 seems only to require the terminal claw or claws to complete it. From the nature of its last-preserved joint it is highly probable that it once supported a double claw, like the Eurypterid foot described and figured by me in the *Transactions* of the Royal Society of Edinburgh, which it closely resembles, and which was obtained from the same beds at Langholm as the *E. scabrosus*. The little projection on the upper side of the terminal joint,[1] which is now bent round in fossilization so as to look backwards, is highly suggestive of that little projection which is found to fold in between the double claws, and also occurs on the foot of the recent scorpions. In the same volume of the *Transactions* of the Royal Society of Edinburgh, comb-like organs, sculptured with the characteristic Eurypterid markings, were figured and described. Since the publication of these, several more perfect specimens of these comb-like appendages have been added to the Geological Survey collections. This, taken in consideration with the fact that Eurypterid fragments abound in the beds representing almost every carboniferous land surface, together with the remains of plants and such undoubted land animals as scorpions, and that they have been found trapped in tree stumps, with only land shells, gally-worms, and air-breathing reptiles for companions, affords a strong presumption that those of this age were land animals and air breathers.[2]

Even were it to be proved that they had been aquatic animals, the *E. scabrosus* and other described carboniferous

[1] Trans. Roy. Soc., Edinb., vol. xxx., pl. 28, figs. 11 and 11*a*.

[2] In the second edition of his "Acadian Geology," Sir J. W. Dawson describes the remains of Eurypterids as occurring in the erect tree stumps of the Joggins coalfield. He hazards the conjecture that the fragment may represent the dermal coating of reptiles, such as his *Dendrerpeton*, p. 372. The figures 143 *f* and *g*, and 144 *e-o*, given on pp. 369 and 373 of that work, leave no doubt as to the nature of the remains, as they exhibit the characteristic sculpturing of the Eurypterids. On fig. 144 *l*, p. 373, in all probability is shown a portion of one of their comb-like organs.

Eurypterids differ so much in the construction of their limbs from the *E. remipes* of Dekay, the type of the genus, that they would require to be placed in a new one, for which I proposed the name *Glyptoscorpius*.[1] As the above-described carapace differs from any hitherto figured or described, I propose to call it *Glyptoscorpius Kidstoni*, after the distinguished botanist, Mr Robert Kidston.

The squamiform ornamentation has hitherto been considered as characteristic of the Eurypterids. It would therefore be of interest to see whether it was confined to them. It has already been shown above that it is not so, for it occurs on the tests of their near congeners, the trilobites, the peculiarly Silurian family of the Asaphidæ. Salter says of *Asaphus tyrannus*,[2] "The sculptured lines, which are veritable plicæ or folds of the crust, are wavy and interrupted, following a general curve all round the margin, but sinuous and inosculating with each other." Again, speaking of *Illænus Barriensis*,[3] "The whole head is covered with the peculiar squamous lineation characteristic of the Asaphidæ. Among recent or fossil crustacea (the trilobites, owing to their arachnid affinities, being excepted) such markings may be looked for in vain, but a similar sculpturing is to be found on the limbs of the recent arachnids, the phalangids or harvest-men."

part of the animal to which they had belonged was not clearly demonstrable.

A peculiar interest centres in this specimen, owing to its occurring in the highest Coal-measures of this country, and is found along with plants which, on the Continent, pass up into the Permian beds. This, therefore, shows that Eurypterids, as such, probably survived till the end of the Palæozoic period.

Dimensions of Carapace.

Greatest length,	19 mm.
Greatest width,	23 ,,
Width across central eyes,	20 ,,
Distance of central eyes from posterior margin,	8 ,,
Long axis of central eyes,	1 ,,
Distance of compound eyes from posterior margin,	9 ,,
Distance of compound eyes apart,	7 ,,
Longer diameter of compound eyes,	3 ,,
Shorter diameter of compound eyes,	1·5 ,,
Width of flange as seen on left side,	4 ,,

Description of Plate XX.

Fig. 1. Carapace of *Glyptoscorpius Kidstoni*, natural size.

Fig. 1*a*. Diagrammatic view of under side, natural size.

Fig. 1*b*. Diagrammatic view of fig. 1, magnified to show eyes and nature of ornamentation. The shaded portion shows where the dorsal portion of the test has broken away, so as to expose a cast of under surface.

Fig. 1*c*. Diagrammatic section across eyes, to show the arching of back and folding in of carapace at edges.

Fig. 1*d*. Ditto, longitudinal along central line.

Fig. 1*e*. Diagram to explain the folding in of squamiform ornament from dorsal to ventral surface.

Fig. 2. Outline of upper side of carapace of *Eurypterus remepis*, after Hall, adapted from figs. in Woodward's "Merostomata."

Fig 2*a*. Ditto, under side.

Fig. 3. Carapace of recent scorpion, a little enlarged to compare with figs. 1 and 1*b*.

Fig. 4. Ornamentation of *Illænus*, after Salter slightly magnified, for comparison with that found near antero-lateral margins of fig. 1*b*.

XXXVIII. *Synthetic Summary of the Influence of the Environment upon the Organism.* By J. Arthur Thomson, Esq., M.A., F.R.S.E.

(Read 21st December 1887.)

"The direct action of the medium was the primordial factor of organic evolution."—Spencer.

All naturalists agree in interpreting life as a relation between two facts,—on the one hand the plant or animal, on the other the external conditions. Function is the connecting link between the two facts, and is defined in general terms as action and reaction between the organism and its environment. The organism modifies its surroundings, and is in turn modified by them, and these two processes are the obviously complementary and inseparable aspects of its life. As Claude Bernard says, "the conditions of life are neither in the organism, nor in its external surroundings, but in both at once." The organism, though in itself a true unity of living matter, has its personal identity maintained by streams of energy from without. It is unnecessary to go to the one extreme of regarding the organism as an insulated unity, or to the other extreme of supposing it merely a focus of external energies; the truth of both aspects may be combined.

3. *History.*—Our analysis of the environment must, however, be prefaced with a brief historical note. That external surroundings influence the organism is no new nor theoretical notion. Even as far back as Hippocrates there was recognition of the fact that climate and outside forces change the body, while in common speech and everyday action the fact is constantly assumed. Nor among naturalists who have made special study of the factors causing change, has the importance of the environment been overlooked. Those before Darwin may be divided into two schools, according to the degree of directness which they attributed to outside influence. The one school, represented by Buffon, Treviranus, and Geoffroy St Hilaire, regarded the surroundings as *directly* hammering changes on the organism. The other school, represented by Erasmus Darwin and Lamarck, regarded the environment as only *indirectly* prompting to change. In Darwin's works the only action of the environment which can be said to be much *emphasised* is its indirect destructive action in the struggle for existence. Post-Darwinians vary in the degree to which they allow direct transforming action, in addition to natural selection. Thus it is fair enough to say that Spencer and Semper allow *more* importance to direct external influence, than do naturalists so widely separated as Nägeli and Weismann. To Claude Bernard we owe a clear concrete treatment of physiological problems from the point of view indicated in his definition of life,—as a harmonious interaction between the organism and the physico-chemical ambient conditions.

4. *Analysis of the Environment.*—Those external influences, which have been shown to affect living matter, may be arranged in various ways. They may, for example, be distinguished as animate and inanimate, but the former are comparatively few, and are in most cases resolvable into combinations of the latter, and again some further division of the large sphere of inanimate influence is imperative. Or it may be proposed to distinguish the external influences as either (*a*) chemical, or (*b*) molecular. The first division would include such factors as the chemical composition of the medium and the character of the food; the second set

would comprise influences such as pressure, heat, and lig
The clear division into physico-chemical, biological, a
psychological has also been suggested, the first being i
animate factors, the second animate, and the third includi
those influences which influence the minds (if we may
speak) of animals rather than their bodies. The last-mention
influences are doubtless very important, especially for
Lamarckian, but they hardly come within our present limi
In Comte's plan of a biological course, the environment w
resolved into two portions, to which a third was afterwar
added: (1) astronomical, chemical, and physical factors; (
soil, atmosphere, and water; and (3) the animate surroun
ings, both quantitative and qualitative. The followi
scheme exposes a more detailed combination of previo
suggestions.

Environment.		Organism.	Environment.	
IV.—Vital or Animate.	Man	Form	Man	*IV.—Vital or Animate.*
	Symbions	Colour	Symbions	
	Parasites		Parasites	
	Commensals	Appendages	Commensals	
	Associates	Integument	Associates	
	Neighbours	Skeleton	Neighbours	
III.—Molecular or Physical.	Electricity	Muscular System	Electricity	*III.—Molecular or Physical.*
	Light	Nervous System	Light	
		Sensory System		
	Heat	Alimentary System	Heat	
II.—Chemical.	Food	Respiratory System	Food	*II.—Chemical.*
	Oxygen	Body Cavity	Oxygen	
	Water	Vascular System	Water	
	Composition of Medium		Composition of Medium	
I.—Molar or Mechanical.	Lateral Pressures	Excretory System	Lateral Pressures	*I.—Molar or Mechanical.*
		Growth		
	Vertical Pressures	Length of Life	Vertical Pressures	
		Reproductive System		
	Amount of Space	No. and Sex of Offspring	Amount of Space	
		Development.		
	+ Influences ➤		➤ − Influences	

(1.) The first division includes what may be called molar or mechanical influences, such as the lateral pressures of currents in air or water, the vertical pressure of gravity or of superincumbent masses, and also the amount of space at the disposal of the organism.

(2.) The second division or sheath of influences comprises the influence of food, both as regards quantity and quality, the amount of oxygen available, the quantity of water, the chemical composition of the medium, including soil, water, air, interior of other organisms, and so on.

(3.) The third series are the higher forms of energy,—heat, light, electricity, and magnetism.

(4.) The fourth division includes influences due to other organisms, whether those be simply neighbours, casual associates, true commensals, parasites, or, most intimately of all, symbions. Under this head the influence of man in his work of domestication might also be noted.

5. *Review of Concrete Researches.*—Under the headings just indicated, some illustrative researches must now be noted. Some of those cited are already familiar and classic, others perhaps less so. The text must be read along with the classified bibliography, which is simply intended as an appendix to Semper's well-known work, "The Natural Conditions of Existence as they affect Animal Life" (1880), to which I cannot too strongly express my obvious indebtedness. The majority of the researches here referred to are of a later date than those given by Semper; and it only remains to be added that, in several cases where the literature is legion, (*e.g.*, on the influence of light on vegetation, and on the

pressure of the surrounding medium; and many passive organisms from sponges to trees afford abundant illustration of such shaping influence.

(*c.*) *Vertical Pressure.*—Alteration of pressure affects the growth of plants (33); Rauber and Sachsse (22), experimenting on embryos, showed that augmented pressure tended to alter the shape, *e.g.*, to increase the breadth, while lessened pressure evoked dropsical forms; Regnard (23), Certes (9), and others, have shown that very high pressure induces latent life, etc.; and Romanes (24) has also been working at the effect of pressure on excitable tissues. Under this head the influences of altitude (6, 7, 18), bathymetrical distribution, and the like, ought to be included. Gravity itself is known to be an important factor, influencing phenomena so diverse as the position of material in the ovum before and during segmentation, cell-division, growth of trees, and shapes of mollusc shells (8, 10, 11, 11*a*, 14, 19, 20, 21, 31, 33). Some other mechanical influences difficult to classify are referred to in the bibliography.

II. Chemical Influences.

(Bibl., 35-111.)

(*a.*) *Amount of Oxygen.*—In a broad shallow vessel with consequently good aeration, Yung's tadpoles (70) developed more rapidly. Gratacap (47) observes that increased oxygen makes insects at first very restless and active. An overplus of oxygen evokes strong movements in a *Paramœcium*, and, according to Rauber and Sachsse (57), quickens the embryonic development of fishes and amphibians in the region of the gill-slits. A superfluity of oxygen has been shown (51) to affect the formation of pigment in frogs. On the other hand, Fiszer (41) observed that deficient oxygen quickens the pulsations of the contractile vacuoles of Infusorians, just as it would make a flame leap and quiver.

(*b.*) *Amount of Moisture.*—Drought is often followed in some of the lower animals by encystation, desiccation, and latent life. A *Pontederia* has a spongy airy stem in water, very different from that which it exhibits when on shore; and other changes in plants have been associated with the amount

of moisture (49, 59). The degree of moisture has a marked effect on the growth of the mantle of molluscs. The well-known case of the transition from Axolotl to Amblystoma (67) may be recorded under this head.

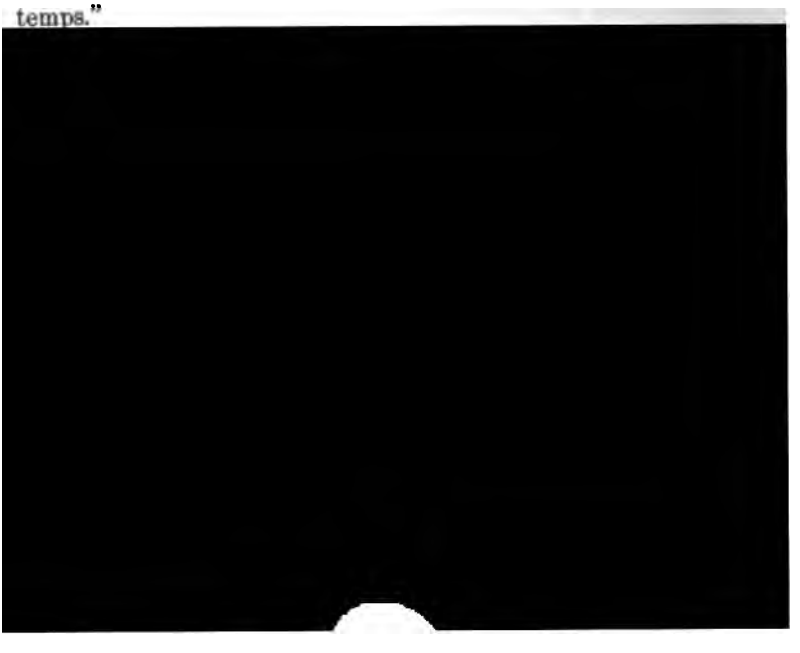
(*c.*) *Composition of the Medium.*—In spite of certain strictures (37, 38), the classic experiments of Schmankewitsch (60) are still accepted to this extent at least, that by altering the salinity of the water he was able gradually to change one species of *Artemia* into another. There are numerous experiments on record as to the effect of transferring organisms from one medium to another (35, 40, 55, 56, 58, 65, 66), and Sollas's observations (63) on the origin of fresh-water fauna are in this connection of great interest. Alteration of salinity has been shown to influence form (61), rate of development (69), colour (60), and even affects the characters of the blood-corpuscles (40), etc. The elaborate researches of Fredericq (43, 44) are in this connection of great importance, as showing that the composition of the blood of many animals undergoes change with alteration of salinity. Krukenberg (50) has also recently made a long series of observations on the relation of the composition of Medusæ to that of the surrounding medium. Very fundamental are the elaborate researches of Frommann (45) on the reactions of protoplasm and cells to external chemical influences. Zacharias (70) made sperms

Copious nutrition is well known to favour not only increase in size, but asexual reproduction, which is only a process of more or less continuous growth. With abundant nutrition a plant may go on reproducing asexually by stolons, etc.; if the nutrition be checked in root pruning, etc., sexual reproduction is incited. That scarcity of nutrition is one of the conditions of the change from parthenogenesis to sexual reproduction in Aphides is probable; and Keller (91) has recently shown that stoppage of nutrition in *Phylloxera* causes the parthenogenesis to cease. Good nutrition, ovarian, uterine, or larval, tends to the production of female, rather than of male forms. It is the peripheral and better nourished cells in the alveoli of the hermaphrodite glands of snails which form ova (100), while those more central become spermatogonia. Wilckens and others (107, 83) conclude that better maternal and embryonic nutrition tends to female offspring. Macé (95) observes that the embryos of *Ascaris dactyluris*, developing in anabolic conditions within the mother, were all females. Yung (108) greatly increased the proportion of female tadpoles, by increasing the quantity and quality of the food. Rich nutritive environment may apparently replace the necessity of male stimulus (90, 106). In a wider connection, Sutton, in his suggestive "General Pathology" and elsewhere (104, 105), has laid great stress on the importance of hypertrophy in evolution, believing that it is the principal process in the transition from hermaphroditism to unisexuality.

Scarcity of food has been shown to have opposite effects to those above stated in regard to abundance; tending to reduction of size, to sexual not asexual reproduction, to the production of males rather than of females. Zacharias (110) has made the interesting observation, that with abundant nutrition a certain Planarian went on reproducing asexually, while checking the nutrition stopped the process. In abundant nutrition Infusorians go on reproducing rapidly by fission; with less luxurious diet the rate is decreased; at low ebb they conjugate (96, 97, 98, 86). To Rolph (101*a*), and others, conjugation has seemed almost identical with the satisfaction of hunger. Reduction of nutrition appears to be a condition necessary for the conjugation of the spores

of Distichiasis [71]. The connection of periods of fasting with the stimulation of sexual climax has been repeatedly noticed [82, 84]. Barfurth has recently directed attention to the importance of fasting in development (72, 73, 74, 75), and the title of one of his papers, "Der Hunger als biologisches Prinzip in der Natur," is sufficiently suggestive. Hoffman [88, 89] notes some cases of the hereditary transmission of characters acquired by certain plants as the result of deficient nutrition. A starved Amphibian may be kept for two years in larval form; with insufficient food certain insect larvæ do not form the usual cocoon, and the pupæ are smaller; starved caterpillars and tadpoles tend to become males, and so on [83, 84, 87, 101*a*, 108]. Finally, there are many changes, from the colour of feathers to the coating of the stomach, which are well known to be associated with changes of diet.

In its influence, both on the vegetative and reproductive systems, food is undoubtedly one of the most important environmental factors. To Claude Bernard, the whole problem of evolution was very much a question of variations in nutrition. "L'évolution, c'est l'ensemble constant de ces alternatives de la nutrition; c'est la nutrition considerée dans sa réalité, embrassée d'un coup d'œil à travers le temps."



at any rate, increase of heat must be regarded as a katabolic condition. Various experiments have been made on the adaptation of organisms to increased temperature (134), and Dallinger's (116) recent elevation of monads from life at 65° F. to life at 158° F. are particularly noteworthy.

Cold has, of course, generally a reverse action, checking activity, finally producing coma, diminishing the rate of development, and tending to produce dwarf or even larval forms (113, 115, 120, 132, 134, etc.). Laboulbène (126) notes how low temperature and damp atmosphere may retard for years the development of the embryo of *Ascaris lumbricoides*, which normally requires only a month or so. Réaumur's classic experiments on aphides show that the cold of approaching autumn is one of the conditions of the return of males; and various suggestive observations have been made on the relation between temperature and sex (121, 124, 129, 133, 138). That alterations of climate in the past may have had important modifying influences on organisms is extremely probable, and Weismann (137) has given a full discussion of this factor in reference to the seasonal demorphism of some Lepidoptera.

(*b.*) *Light* (140-189).—A beam of light shed on a giant amœba (*Pelomyxa*) causes a shock-like shrinking, and a general contraction is common among higher forms (144, 161). The majority of animals avoid strong illumination, but not a few are as markedly light-seeking (150, 151, 152, 161). It is possible that some of the incipiently-eyed and many-eyed lower animals may absorb solar energy, and deserve the title "heliophagous" (158*a*). Light is believed in some cases to affect the colours of animals (156), and this seems demonstrable in the familiar instance of bird's eggs (157). Yung has made an elaborate series of experiments (181-189) on the influence of differently coloured light on the development of tadpoles, while Poulton's beautiful researches (163, 164, 165) on the influence of coloured surroundings on insect larvæ and pupæ afford one of the best illustrations of a very subtle environmental influence. Héron-Royer (153) quickened the development of the larvæ of Bombinator by prolonging the conditions of daylight.

That light may influence animals quite apart from their eyes has been repeatedly shown, especially by Plateau (161*a*, 162); many tracheate Arthropods are indisputably "dermatoptic." Some other influences of light are noted in the bibliography.

In relation to plants, light is well known to have a yet more important and very varied action, *e.g.*, on the interchange of gases, on the disposition of chlorophyll, on the direction, expanse, and distribution of leaves, on the number of stomata, on the histology of the leaf, on plant movements, and so on (141-143, 148, 160, 166, 167, 172-175, 177, 179, 180). Light is even a factor in variations of reproduction among algæ, *e.g.*, in *Botrydium*. It is now a familiar fact that strong sunlight, and not heat, is the most potent and universal antagonist of germs.

The absence of light stimulus can hardly be denied to have a share in the degeneration of animals living in dark regions (146, 147, 158, 159, 168, 170; *cf.*, however, 178). Darkness is unfavourable to the development of some caterpillars, and also influences tadpoles (154, 155, 181-189). Schneider (168) has recently noted that subterranean conditions tend to produce reversion to young or embryonic conditions. According to Strethill Wright, polypes of the higher Acalephæ kept in darkness multiply abundantly by buds only, while in the light and with insufficient supplies

influenced directly. It would be idle to assert that flowers had suffered no mechanical modifications from the visits of insects, or that ants and other visitants have come and gone for millennia without leaving traces of their direct work. Especially where organisms have become constantly associated does the influence make itself markedly felt. Thus Semper (204) notes how the influence of sea-spiders (*Pycnogonidæ*) on Hydroids acquires the constancy of a specific character, and refers to the mutually influential associations of a *Buccinum* and a Gorgonia, of an Annelid and an *Antipathes*. The characters of *Tubularia parasitica* lately described by Korottneff (199*a*) cannot be understood apart from the limitations of the Gorgonia which it inhabits; and F. E. Schulze (203), in his recent Report on the "Challenger" Hexactinellida, notes how commensal polypes (*Stephoscyphus mirabilis*) have wholly altered the form of a sponge *Myxilla*. Kossmann (204) explains the asymmetrical growth of a parasitic Crustacean (*Pachybdella*) as the direct result of pressure, as at first abnormal, but now inherited. Giard (198) has lately described how the parasitic Crustacean *Sacculina*, infesting the sharp-beaked crab *Stenorhynchus*, has affected copulatory appendages and other sexual characters almost to the degree of castration. In a later paper (199) he has given other instances. That parasites (200) may exert distinct influence on their host, as well as *vice versa*, goes without saying; inflammation, rupture, choking, deterioration of juices, and other effects less disadvantageous, may result; and Roux (202) notes how even changes in the capillaries and histology may be effected by a parasite. That true symbions must have an important influence on function is also obvious. A simple reference to the direct influence of man in domestication may fitly close this catalogue of environmental influences.

6. *Physiological Classification of Results.*—The environmental influences may also be classified according to the various systems affected. Such a classification, from the organism point of view, might follow the usual series of systems, as indicated in the middle column of my table. Certain conditions, especially of a mechanical and quantita-

tive character, affect the vegetative system; others, such as heat and markedly varied nutrition—more of the nature of real stimuli—operate on the reproductive energies. Some influences, such as light, are more important in regard to the sensory and nervous systems of animals, while others of a grosser nature affect more conspicuously other parts of the organism. Or again, modifying the central column of my diagram, the progress of research should make it possible to draw up a series of tables in which the influence of external factors (such as heat) might be illustrated in operation on the protoplasm, on the cells, on the tissues, on the organ, on the organism as a whole, and even on the species. In regard to general adaptation, such an analysis has been sketched by Münsterberg, but in spite of fundamental researches like those of Frommann, the relative scantiness of available material makes such a task as yet premature. It hardly needs to be stated that except in the case of mechanical factors, like currents, the influence affects the protoplasm first, and thence saturates throughout the system. The organism cannot be supposed to react directly to external influence, as litmus paper to an acid.

7. *Physiological Rationale of Environmental Influence.*—In many cases it is easy to understand why a given external change should be followed by a definite organismal variation.

the like. The most satisfactory *rationale* of a set of environmental influences known to me is that given by Geddes in his papers on sex (83, 84), where he shows that the conditions favouring the production of male offspring are generally katabolic, and those favouring the production of females are similarly anabolic. This result, reached by adding up the observations of numerous investigators, is in beautiful harmony with the conclusion which he has reached along other lines—that the male is a relatively katabolic, and the female a relatively anabolic, organism.

8. *Susceptibility to Environmental Influence.*—In estimating the probable historic influence of the environment, it must be allowed that organisms are variably susceptible to external influence, and that some factors are much more potent than others. The chemical character of the medium, nutrition, heat, and light are evidently more influential external conditions of variation than pressure, electricity, or animate surroundings. It is equally obvious that simple and young forms are more in the grip of external surroundings than are complex and adult organisms, so that "the direct action of the medium" was much more important as a "primordial factor of organic evolution" than in later days.

The Protozoa and Protophyta are evidently much less emancipated from their environment than higher forms. They are saturated by their surroundings in a sense which cannot be maintained of higher unities except in their germinal stages, and they are well known to be impressible to a degree impossible in the higher animals and plants. On the other hand, many of the higher organisms live in a more complex environment, with which they are connected in subtler and more numerous relations. Claude Bernard (247) distinguished three degrees of independence in relation to the environment—(1.) *latent life*, as in seeds, germs, encystations, and desiccated organisms; (2.) *oscillant life*, as of plants in winter, or of hybernating animals; and (3.) *constant life*, as of higher organism.

Another contrast is very evident. Passive forms, like sponges and algæ, corals and trees, are much more in the grip of their environment than are active forms like insects

and birds; but their surroundings have a much more restricted character. Thus we find sponges, corals, and shells moulded as regards their external form by currents, just as trees are blown into shape by the wind. But the variations so produced are, comparatively speaking, small details. Dall (206) notices in regard to deep-sea molluscs, where the changes in environment are obviously few, that the number of individual variations in form and sculpture is often great, but the number of "flexible species" few. Similarly the comparatively long-lived and passive leaves of plants are subject to numerous variations, in many cases doubtless environmental, while the short-lived and relatively active reproductive leaves are much less subject to detailed environmental variations. Differences in the reproductive organs of plants can indeed be rarely associated with environmental influence except in the cases of mechanical modifications due to insects. As with less passive organisms, so with less vegetative parts, they are less in the grasp of their environment.

Yet active organisms come within a richer and more variable circle of influences, some of which have doubtless had a directly modifying action; and it is significant in this connection to notice that the passive forms, with limited environment, are relatively unprogressive. In appreciating the limitations of forms like sponges, echinoderms, or bivalves,

9. *Degrees of Environmental Influence.*—It is obvious, from the illustrations which have been given, that the environment may condition changes varying greatly in their degree of directness. If the environment remain constant, it is assumed that it will preserve the organism *in statu quo.* If it change, there may be the following different modes of action:—

(1.) When an Amœba shrinks up under a sudden beam of light; when a drop of dilute ammonium carbonate brings down a sun-animalcule from its normal heliozoon form to an amœboid phase; when other influences reduce ciliated cells, or even sperms, to the amœboid level; when the Infusorian pulsates violently in deficient oxygen; when heat increases their locomotion; change within the organism may be said to follow as the direct result of change in external conditions. The simplest cases of all are those in which a surplus of some form of energy, such as heat or food, is received by the organism, and forthwith expressed in some probably equivalent organismal change. In higher organisms, and with more complex environment, though we can still say that altered conditions have been followed by a certain change, it is, as yet, impossible, in the majority of cases, to form any conception of the series of changes from the original external one to the final internal result, impossible also to say how far the internal modification is proportionate to the external change, or how far it is the result of a series of changes to which the new stimulus simply gave the initial impulse, as the pulling of a trigger to the discharge of a rifle. But still it seems legitimate to regard a large number of instances as internal variations directly conditioned by external changes.

(2.) All who have attacked the problem of variation have allowed that one variation may bring another in its train. A change in respiration may bring about a change in circulation; a change in the nervous system may be followed by a change in the muscular. And thus a second category may be established for secondary or correlated internal variations, consequent on primary environmentally conditioned changes.

(3.) When the organism immediately responds to a change in outside conditions, its action may, in many cases, be described as a direct parry; and in some cases this appears

to be plausibly referable to direct environmental influence. In other cases the organism asserts itself, in relation to the environment, by what may be described as a thrust. Now, without denying the possibility of distinguishing distinctly internal or independent organismal variation, it is necessary to admit the possibility of environmental influences remaining long dormant, being slowly added up within the organism until they finally express themselves in what, in one sense, comes from within, but, in another sense, comes as truly from without.

(4.) When animals are kept in a confined space, or in other changed external conditions, it has been shown that a pigmy brood may be the result. But this only shows itself in the course of generations. The transition from one species of brine-shrimp to another, effected by altering the salinity of the water, required a succession of generations. It seems probable that this must have been the case in all the supposed environmental modifications, which have been of historic importance. Thus we may define a fourth category of environmental variations, which may not be very appreciable in the individual, except in affecting the reproductive elements, through which the changes become expressed in the offspring. Barfurth (224), for instance, notes how in the trout the absence of suitable spawning ground conditions (1st) reten-

This general action, followed, of course, by others, must also be allowed.

(7.) While anything of the nature of cataclysmic action is regarded with just suspicion, there can be no doubt that unusual environmental conditions may affect crowds of organisms in a somewhat wholesale way. Thus Rupert Jones (212) gives a list of the various conditions which may affect a whole series of organisms, or even a fauna.

(8.) Lastly, it is enough to notice, that if we regard the environment as comprising animate, as well as inanimate, external influences, the effect of multiplication of rival competitors within a species, and of inimical members of other genera, may affect the organism not only directly, but also indirectly, through the inanimate environment. This category of influence is familiarly included in the conception of the struggle for existence, or of natural selection.

10. *Periods of Environmental Influence.*—It is also instructive to classify the influences in order of time. (1.) Influences begin to operate upon the germ-cells *in situ*. According to its position, the ovum will be subject to varying nutritive conditions. In some cases the ultimate ova are the most successively nourished individuals among a crowd of unsuccessful competitors. In the primitive hermaphroditism, said to occur in the history of many unisexual forms, the predominant nutrition of certain areas is doubtless of importance. Sutton (*op. cit.*) maintains the general proposition that hermaphroditism is primitive; that hypertrophy is at least one of the processes in the differentiation of the separate sexes; and that "reproduction in Vertebrata, so far as is known, is impossible, unless hypertrophy of one set of organs occurs." Roux (*op. cit.*, 222) has shown that definite injuries to the ovum produce definite defects in the embryo.

(2.) The stimulus of the male element is another influence *ab extra* on which various naturalists (*e.g.*, Treviranus, 259; but especially Weismann, 244) have laid emphasis. The case of bees, as usually interpreted, is a familiar illustration of importance in this connection. The difference in the maturation of parthenogenetic and normal ova (established by Weismann and others) ought also to be noted. It is again

generally believed that the condition of the reproductive products, at the time of fertilisation, has some influence on the sex, etc., of the offspring. And in regard to hybridisation, which, for all we know, may have been of some importance in the past, the recent experiments of the brothers Hertwig demonstrate the importance of the condition of the elements.

(3.) During the period of embryonic life, environmental influences may effect very fundamental changes, whether the embryo be within or outside the parent. The effect of different nutrition on bee grubs at once suggests itself. By varying the nutrition of his tadpoles, Yung was able very widely to alter the normal proportions of the sexes. Experiments on other young forms have been noticed above.

11. *Relation of Environmental Modification to Heredity* (223-246).—Till comparatively lately it was assumed that characters acquired by an individual organism, and in no sense part and parcel with its inherited constitution, might yet be handed on to the offspring. Once acquired, the possibility of their transmission was hardly doubted. Even Darwin, however, came to feel the great probability against the retention of individual variations. Weismann has brought the doubt to a climax, by a point-blank denial of the transmission of individually acquired characteristics. This he does partly on the ground that positive proof is in his opinion wanting, and

the general organism may rapidly affect even the reproductive elements. If Sedgwick's view of the syncytial or plasmodial constitution of the embryo Peripatus be confirmed and extended; if protoplasmic continuity, so widely demonstrated in plants, be also, to some extent, true of animals, then our conception of the diffusion of a change will have to be modified. The question, in fact, is not whether direct environmental action may occur or not, nor whether it may be inherited or not, but simply how soon the influence may so saturate through the organism, as to become, by affecting the reproductive elements, transmissible.

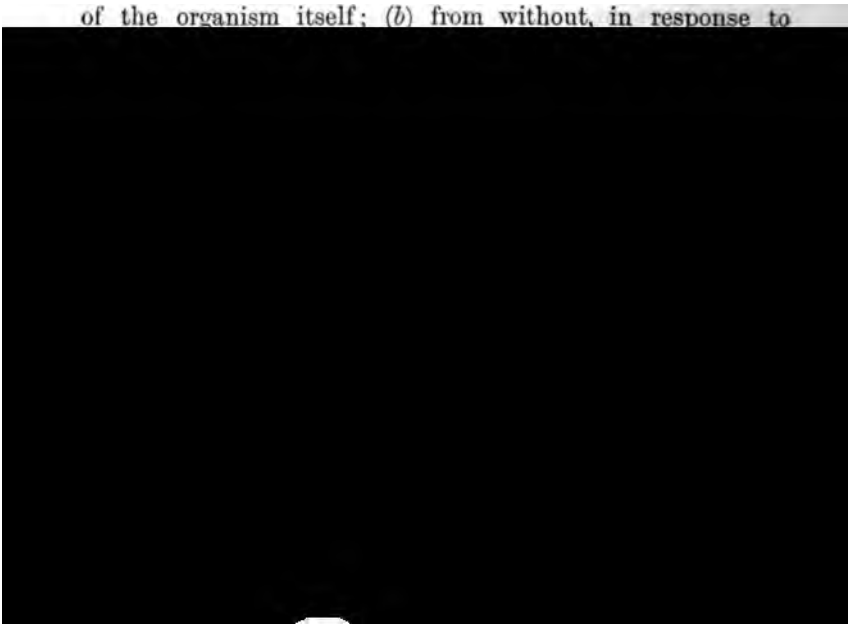
12. *Relation of "Environmental" to other Variations.*—Without forestalling the last division of this paper, it may be convenient to note the relation of environmental to other variations. Combining the various theories of the conditions of change, we may describe variations as originating (*a*) from within, (*b*) from without, and (*c*) in the course of function. Variations may originate, according to some (*e.g.*, 210), strictly from within, because of the unstable complexity of internal structure—protoplasmic or otherwise—which makes equilibrium all but impossible. These (*a*) may be spoken of by themselves as "organismal variations." According to others, they may originate in the way above described from the varying nature of external influences. These (*b*) may be termed "environmental variations." Or changes may be brought about by altered activity, itself a response to altered relations of the organism and its environment. Those (*c*) variations especially emphasised by Lamarck, may be conveniently described as "functional."

13. *The Action of the Environment as a Factor in Organic Evolution.*—The history of opinion in regard to the action of the environment as a factor in organic evolution, may fairly begin with Buffon. In his writings from 1749 onwards, Buffon makes it evident that he believed the surroundings to be a direct cause of variation within the organism. He is, in this respect, contrasted with Erasmus Darwin (1794), who credited the surroundings with a merely indirect modifying influence. Herder too, in his discussion of human races, laid emphasis on the influence of heat and climate; while

Goethe, with greater concreteness, spoke quite definitely about the modifying influence of food, light, humidity, and the like. Lamarck (1802) developed the same opinion as Erasmus Darwin, and regarded changes in surroundings as prompters of change in function, which was to him the all-important factor. In marked contrast to Lamarck stands his contemporary, Treviranus (1802), who insisted with greater wealth of illustration on the direct hammering action of the environment. Geoffroy St Hilaire (1830) swung round to a strictly Buffonian position, and regarded the direct action of external forces as the all-important factor in modification. Robert Chambers (1843) allowed that physical forces in some way governed the process, especially in their action on the generative system.

In 1852 Spencer combined the views of Buffon and Lamarck, maintaining that "under new conditions the organism immediately begins to undergo certain changes in structure, fitting it for its new conditions." If the new influences persist, the changes in the organism are confirmed in continued function, and perpetuated in heredity.

Up to this point in the history it had been suggested that variation might be either organismal, or environmental, or functional, arising (*a*) from within, because of the complexity of the organism itself; (*b*) from without, in response to



coast clear for the minority of fit variations, which throve and bred better, and thus gradually established adapted species. The merits of his theory are not at present under discussion; its relation to the general conception of environmental influence must, however, be noted. While several passages (especially of later date) fully recognise the Buffonian position, Darwin may be fairly said to have laid greatest stress on the *destructive* action of the animate and inanimate environment.

A few post-Darwinian positions may also be noticed. Hæckel, surpassing Darwin in the clear perspective in which he placed the various factors, defines adaptation as "the fact that the organism, in consequence of influences from the surrounding external world, acquires certain new peculiarities in life capacity (Lebensfähigkeit), constitution and form, which were not inherited." This definition may not be above criticism, but it is for our present purpose more important to notice one of his eight laws of adaptation, that, namely, in which he formulates the result of the persisting influence of food, climate, medium, function, etc.

Semper, again, distinguishes with perfect clearness those modifications, which, as a Darwinian, he believes to be due to the action of natural selection, from those which have resulted from the direct hammering of the environment.

Even Nägeli, who more than any other has given precision to the conception of independent internal or organismal variation, calls in the aid of external influences to act, on the one hand, as a stimulus, and on the other, to form, as it were, the mould to which the organismal variation adapts itself.

It is important to note Weismann's positions. In his "Studies in the Theory of Descent," he affirms that there can be no progress apart from environmental changes; he allows the existence of a direct hammering action, though justly cautious as to the extent to which it really exists. Its action is limited internally by the constitution of the organism; and important as this direct action may be, the indirect action in the process of natural selection is a much more vital factor in progress. In contrast to Nägeli, he is quite definite in regarding the environment, in its widest sense, as

the dynamical impulse in evolution. As he had hinted in this work, he subsequently laid great emphasis on the action of sexual reproduction as a condition of variation; and, in a sense, the stimulus of the male element may be ranked among the external influences. Very important in all attempts to estimate the action of the environment is Weismann's recently developed position, that individual characteristics impressed upon an organism, in response to outside influences, cannot be shown to be hereditarily transmissible. Only when the influence has had time to saturate through the organism, and affect the reproductive elements, can the inheritance of acquired characteristics be allowed. But a due discussion of this caveat will require a separate paper.

Roux, who has especially attacked the problem of the mechanics of development, distinguishes *self-differentiation*, where the specific nature of the modification is determined by the energies of the system, from *correlative differentiation*, or change determined by action and reaction between the system and its environment. In marked antithesis to the opinion that environment has a direct transforming action, it is interesting to notice the statement of Meehan, who has worked especially at the botanical side of the subject. He says "environment seems to have no further influence than to incite to action a change already ripe for development.

a cause, both direct and indirect, of modifications of structure. Sexual reproduction also caused frequent and fortuitous variations. The result of mixtures of constitutional proclivities were mostly suppressed, but sometimes increased by survival of the fittest. Natural selection became the predominant factor in relation to fortuitous variations of structure, of no account in converse with the medium, of much account in the struggle with enemies and competitors. Especially with plants and passive animals the survival of fit variations must all along have been the chief cause of the divergence of species and the occasional production of higher ones. Gradually the inheritance of those modifications of structure, caused by modifications of function, becomes more and more important." A synthesis of all the positions is thus again outlined, differing from the view expressed in the *Leader* article of thirty-four years previously in even more definite insistence on environmental influence, and in the recognition of the struggle for existence, differing, too, from his intermediate contributions in a marked tendency to limit the importance of the struggle, *i.e.*, of natural selection.

A general view of the factors of evolution is still being evolved, and it is premature to speak of final form. Yet this much seems certain, that no attempt to explain the adaptation of the organism to its environment can be complete without a recognition that external influences in the widest sense, and in various degrees of directness, have and have had an important transforming and adaptive action. To place this opinion in its proper perspective in relation to organismal and functional variations, or in reference to natural selection and other alleged conditions of progress, will remain impossible until a greater wealth of experimental fact makes it possible to say with security what the environment can or cannot do. The main object of this paper, based, as I must again gratefully acknowledge, on Semper's classic work, has simply been to present anew a balance-sheet of representative facts and opinions in regard to environmental influence.

LIST OF RESEARCHES REFERRED TO.

N.B.—Abundant references to literature are to be found in the appendix to Semper's "Animal Life," 1880. The majority of the researches cited below are of later date.

The few sample researches on the environment of plants may be supplemented by reference to Prof. Sachs' "Lectures on the Physiology of Plants" (translated by Prof. Marshall Ward), and to Prof. Vines' "Lectures on the Physiology of Plants" (1886), *e.g.*, in the Bibliography to Lecture XVI., pp. 414, 415.

I. Molar or Mechanical.

(1-34.)

1. Amans (no init.). Généralités sur les organes de locomotion aquatique. Comptes Rendus, cv. (1887), pp. 1035-37.

   Mechanical study of modes of aquatic locomotion, with emphasis on "the enormous influence of the resistance of the water on the forms of the body and appendages."

2. Balaschewa. De l'influence du milieu extérieur et principiellement celle des dimensions du bassin d'eau sur quelques Mollusque. Mem. Soc. Nat. Nouv. Russ. Odessa, xii., 1 (1887).

3. Barfurth, D. Biologie der Forellen. Arch. mikr. Anat., xxvii. (1886), pp. 121-178, 2 pls.

8. Born, G. Ueber den Einfluss der Schwere auf das Froschei. Breslauer Aertztl. Zeitschr., No. 8, 1884.

9. Certes, A. De l'action des hautes pressions sur les phénomènes de la putrefaction et sur la vitalité des micro-organismes d'eau douce et d'eau de mer. Comptes Rendus, xcix. (1884), pp. 385-388. *Cf.* Journ. d. Micrographie, viii. (1884), pp. 291-293.

10. Conn, H. W. Life-History of a Thalassemid. Stud. Biol. Lab. J. Hopkins Univ., iii. (1886), pp. 351-399.

Regular segmentation associated with free life; irregular with protection or encapsuling. The cause mechanical, —gravity.

11. Elfving. Beitr. zur Kenntniss der physiologischen Einwirkung der Schwerkraft. Helsingfors, 1880. Quoted by Vines—Lectures on the Physiology of Plants, p. 409.

11a. Hertwig, O. Beiträge zur Morphologie und Physiologie der Zelle. Welchen Einfluss übt die Schwerkraft auf die Theilung der Zellen. Jena, 1884 (also in Jen. Z. Nat.).

12. Fuchs, R. Mikromechanische Skezzen. Kosmos, xviii. (1886), pp. 183-199, 285-302, 416-441.

Molecular dynamics of protoplasm, with special emphasis on the contraction and expansion of the surfaces of contact between two soft bodies.

13. Hiern, W. P. A Theory of the Forms of Floating Leaves in Certain Plants. Proc. Cambr. Phil. Soc., Part xiii., 1872.

Mathematical investigation of most mechanically suitable forms.

14. Loob, J. Die Orientirung der Thiere gegen die Schwerkraft der Erde. (Thierischer Geotropismus). Würzburg, 8vo, 1888.

15. Marcacci, A. Dell' influenza che esercita il movimento sullo sviluppo dell' uovo. Ann. Univ. Perugia, vol. i., 1885-86.

16. ———. De quelques anomalies obtenus dans les œufs de poule en les soumettant au mouvement. Arch. Ital. Biol., ix. (1887), p. 58.

17. NATURE, xxxiii. (1886), pp. 607-609. Plants considered in Relation to their Environment.

18. PELLAT, A. Bull. Bot. Soc. de France, p. 105, 1880, also 1879. (Influence of Altitude on Plants.)

19. PFLÜGER, E. Über den Einfluss der Schwerkraft auf die Theilung der Zellen. Arch. f. ges. Physiol., xxxi. (1883), pp. 311-318.

20. ————. Über den Einfluss der Schwerkraft auf die Theilung und auf die Entwicklung des Embryo. Arch. f. ges. Physiol., xxxii. (1883), pp. 1-79, 2 pls.

21. ————. Über die Einwirkung der Schwerkraft und anderen Bedingungen auf die Richtung der Zelltheilung. Arch. f. ges. Physiol., xxxiv. (1884), pp. 607-616.

22. RAUBER, A. (in conjunction with R. Sachsse). Über den Einfluss der Temperatur, der atmosphärischen Druckes, und verschiedener Stoffe auf die Entwickelung thierischer Eier. SB. Nat. Ges. Leipzig, 1883, pp. 55-70.

Pressure determining form. Increased pressure alters shape, *e.g.* broadening. Lessened pressure may produce dropsical swollen forms.

23. REGNARD, P. Action des hautes pressions sur les tissus animaux. Comptes Rendus, cii. (1886), pp. 173-176.
Ibid. xcviii. (1884)

28. Semper, K. Über die Wachsthum-Bedingungen des *Lymnæus stagnalis.* Arb. Zool. Inst. Würzburg, T. i. (1874), p. 137. *Cf. op. cit. supra.*

29. ———. *Op. cit. supra.*

Axolotls reduced to sterility for two years by removing objects for egg-deposition. Production in cramped space of dwarf broods (Asellus, Lymnæus).

30. ———. *Op. cit. supra.*

Effects of currents on shells, coral growths, etc.

31. Spengel, J. W. Schwerkraft und Zelltheilung. Biol. Centralblt., v. (1886), pp. 663-668.

Historical notice of some of the numerous investigations. (Born, Hertwig, Pflüger, etc.)

32. Tichomiroff, A. Die künstliche Parthenogenese bei Insekten. Arch. f. Anat. u. Physiol., Suppt. Bd. (1886), pp. 35, 36.

Artificial parthenogenesis induced by mechanical stimulus.

33. Vines, S. H. *Op. cit.* Gravitation, p. 409. Influence of Currents, p. 473, etc.

33a. Wiesner, J. Biol. Centralblt., vii. (1887), p. 21. Akad. Wiss. Wien, 1887.

Influence of wind on transpiration and stomata.

34. Yung, E. L'influence des milieux physico-chimiques sur le développement des animaux. Archiv. Sci. Phys. et Nat., xiv. (1885), pp. 255-257.

The fewer tadpoles in a given space, the quicker the development.

II. Chemical.

(*a.*) Chemical Composition of Medium (35-70).

35. Bert, P. Sur la cause de la mort des animaux d'eau douce qu'on plonge dans l'eau de mer et réciproquement. Comptes Rendus, xcvii., pp. 133-136 (*Cf. ibid.*, 1871, pp. 381 and 464).

Effect of salt water on epithelium, circulation, etc.

36. Brandt, K. Die Sphærozoen. Fauna und Flora des Golfes von Neapel. Monographie xiii. (1886).

Sensitiveness to changes in salinity.

37. Brauer, Fr. Ueber Artemia und Branchipus. Zool. Anz., iv. (1886), pp. 364, 365.

Criticism of conclusions of Schmankewitsch.

38. Claus, C. Untersuchungen über die Organisation und Entwicklung von Branchipus und Artemia. Arb. Zool. Inst. Wien, ii. (1886).

Critique of conclusions of Schmankewitsch as to effects of environment on these forms.

39. Dewitz, J. Kurze Notiz über die Furchung von Froscheiern in Sublimatlösung. Biol. Centralbl., vii., 3, pp. 93, 94.

Corrosive sublimate solution provoking artificial segmentation in unfertilised ova.

40. Eisig, H. Die Capitelliden des Golfes von Neapel. Monographie xvi., Zool. Stat., Naples, 1887.

Experiments on accustoming *Capitella capitata* to live in sea-water (pp. 798-805). The blood-corpuscles must become "hardened" to the change before the transference is successful.

41. Fiszer, Z. Observations sur la vacuole pulsatile des Infusoires. Arch. Slav. de Biol., ii. (1886), pp. 288, 289.

Deficient aeration quickens pulsations of contractile vacuoles.

42. Frankel, A., and Geppert, J. Ueber die Wirkungen der

45. Frommann, K. Untersuchungen über Struktur, Lebenserscheinungen und Reaktionen thierischer und pflanzlicher Zellen. Jen. Zeitschr. f. Naturw., Bd. xvii., 1884. Also separately, pp. 34-36, 3 pls.

Important observations on chemical and other influences brought to bear upon animal and vegetable cells.

45a. Geddes, P. Restatement of the Cell-Theory. P. R. Soc., Edinb., 1883.

46. Graber, V. Vergleichende Grundversuche über die Wirkung und die Aufnahmestellen chemischer Reize bei Thieren. Biol. Centralbl., v. (1885), pp. 385-398, 449-459, 481-489.

47. Gratacap. American Naturalist, xvi., 1882.

Increased oxygen makes insects for a while restless and saltatory.

48. Hertwig, O. and R. Ueber den Befruchtungs-und Theilungsvorgang des thierischer Eies unter dem Einfluss äusserer Agentien. Jen. Zeitschr. f. Naturwiss., xx. (1887), pp. 120-241, 477-510, 5 pls.

Influence of chemical, thermal, and mechanical agencies on—(1.) fertilisation; (2.) internal phenomena of fertilisation; (3.) segmentation.

48a.———. Experimentelle Untersuchungen über Befruchtung. Anat. Anz., i., pp. 11-16.

Inter alia effect of chloral hydrate on fertilisation.

49. Kohl. Die Transpiration der Pflanzen. Braunschweig, 1886.

Dry air—on Tropæolum leaves, thick cuticle, much collenchyma; moist air—little cuticle, no collenchyma.

50. Krukenberg, C. F. W. Die Beeinflussung des Salzgehaltes der lebenden Gewebselemente durch den Salzgehalt der Umgebung. Vergl. Physiol. Studien, ii. 4 (1887), pp. 1-58. (*Cf.* his references.)

51. ———. (See under Light, p. 455.)

Influence of oxygen on pigment forming. Cites Moleschott's observation that a frog kept breathing pure oxygen had no black pigment in its skin, pp. 174, 175.

52. KRUKENBERG, C. F. W. Vergleichend-Physiologische Vorträge vi. Grundzüge einer Vergleichenden Physiologie der Nervösen apparate. Heidelberg, 1886, pp. 397-517.

P. 429. Notes on shifting to medium of different composition. *Cf.* his references (p. 505) to Beudant (molluscs). Ann. de chimie, T. ii., 1816, p. 52. Czerny (Amœbæ), Arch. Mikr. Anat., v., 1869, p. 158, etc.

53. MARCACCI, A. Azione degli Alcaloidi sulle piante, sulle fermentazioni e sulle uova, alla luce e nella oscurità. P.-v. Soc. Toscana di Scienze Naturali (Pisa), vol. v., 1887, p. 285.

E.g., ova of Amphibia under action of quinine did not develop in light, but passed through several stages in darkness.

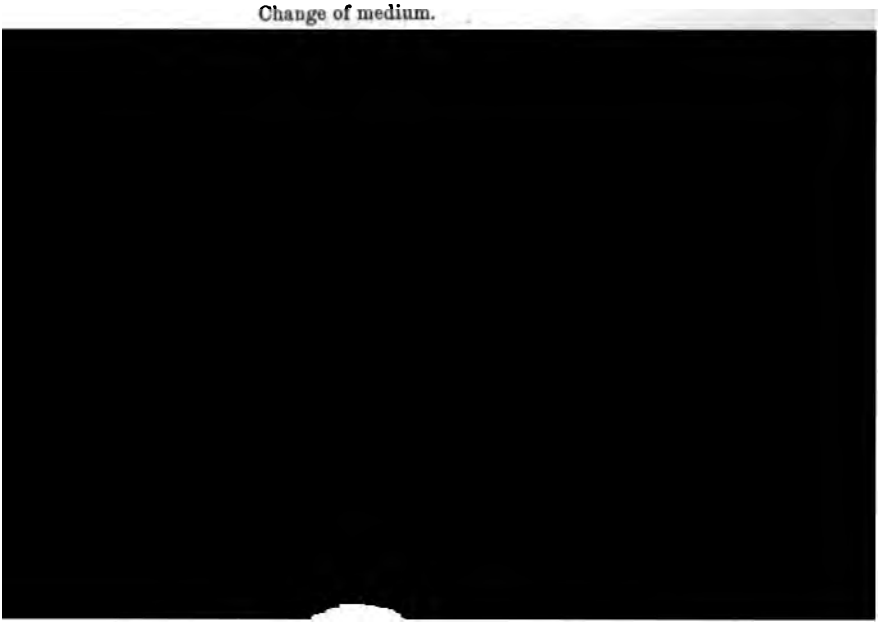
54. MARTENS, E. v. On the Occurrence of Marine Animal Forms in Fresh Water. (Translated paper. Ann. and Mag. Nat. Hist., 1858, ser. iii., vol. i.)

55. PLATEAU, F. Recherches physico-chimiques sur les Articulès aquatiques. Mem. Acad. Belg., xxxvi., 1870. Bull. Acad. Belg., T. xxxiv., 1872.

Changes of medium—water.

56. ————. Influence de l'eau de mer sur les animaux d'eau douce, et de l'eau douce sur les animaux marins. Comptes Rendus, xcvii., pp. 467-469.

Change of medium.



61. Schmankevitch, M. Mem. Novoross. Sve. Nat., vii. Nature xxiv. (1884), p. 274. J. R. Micr. Soc., 1884, p. 69.

Modifying influences (on a Flagellate) of altered salinity (and temperature).

62. Semper, K. *Op. cit.*

Records numerous effects of change of medium and chemical composition.

63. Sollas, W. J. On the origin of Freshwater Faunas: A Study in Evolution. Trans. Roy. Soc., Dublin, vol. iii., pp. 87-118.

Important observations on the conditions of life in fresh water.

64. Tichomiroff, A. Die künstliche Parthenogenese bei Insekten. Archiv f. Anat. u. Physiol. (Physiol. Abth.), Suppl. Bd. (1886), pp. 35, 36.

Parthenogenesis artificially induced by chemical stimuli.

65. Varigny, A. de. Influence exercée par les principes contenus dans l'eau de mer sur le développement d'animaux d'eau douce. Comptes Rendus, xcvii., pp. 54, 55. (See Water.)

66. ———————. Versuche an Beroe ovata, Aurelia aurita, und an Paguren. Biol. Centralblt., vii., 4 (1887), pp. 127, 128.

Effects of altering salinity, etc., on vitality, movements, etc., of organisms.

67. Weismann, A. Studies on the Theory of Descent, 1882.

Discussion and literature of familiar case of Axolotl and Amblystoma.

68. Woodhead, G. S., and Hare, A. W. Relations of Micro-organisms to Tissue Elements. J. of Anat. and Physiol., xx. (1886), pp. 76-99.

"The stimulus applied by the presence of micro-organisms or their chemical products, acts in a manner comparable to action of male element on ovum, in setting up segmentation."

69. Yung, E. (See Light, p. 455.)

In shallow wide vessel, with better aeration and nearer surface, tadpoles develop more rapidly. Dilute sea-water slows development of tadpoles.

70. Zacharias, O. Experimentelle Untersuchungen über Pseudopodien Bildung. Biol. Centralblt., v. (1885), pp. 259-262.

Modifications of cells by external reagents. *Cf.* his references to Schneider, Brass, Kühne.

(*b.*) Food (71-111).

71. Balbiani, E. G. Observations relative à une note récente de M. Maupas, sur la multiplication de la *Leucophrys patula*. Comptes Rendus, civ. (1887), pp. 80-82.

Deficient nutrition, followed by encystation of Infusorian.

72. Barfurth, D. Biologie der Forellen. Arch. mikr. Anat.' xxvii., pp. 121-178.

Connection of nutrition, etc., and sterility.

73. ———————. Experimentelle Untersuchungen über die Verwandlung der Froschlarven. Biol. Centralblt., vi. (1886), p. 609.

Influence of fasting on development.

74. ———————. Die Rückbildung des Froschlarvenschwanzes und die sogenannten sarcoplasten. Arch. mikr. Anat., xxix. (1887), pp. 35-60, 2 pls.

Reduced nutrition associated with death of tissues in absorption of tadpole tail.

75. ———————. (*a.*) Versuche über die Verwandlung der

response to different environment. Many species are only adaptive modifications. Their virulence for one plant may be attenuated by prolonged culture on another.

78. Ritzema-Bos, T. Futteränderung bei Insekten. Biol. Centralblt., vii. (1887), pp. 321-331.

79. Düsing, K. Die Faktoren welche die Sexualität entscheiden. Jen. Zeitschr. f. Naturw., xvi. (1883), pp. 428-464.

Influence of nutrition on reproduction, and on the sex of the progeny.

80. ———. Die Regulirung des Geschlechtsverhältnisses bei der Vermehrung der Menschen, Thiere, und Pflanzen. Jen. Zeitschr. Naturw., xviii. (1884), pp. 593-940, also sep.

81. ———. Die experimentelle Prüfung der Theorie von der Regulirung des Geschlechtsverhältnisses. Jen. Zeitschr. Naturw., xiv., Suppt. (1885), p. 108.

82. Gaule, J. Bedeutung der Cytozoen. Biol. Centralblt., vi. (1886), pp. 345-351.

Influence of fasting periods on reproductive organs, in frog, and in salmon (Miescher).

83. Geddes, P. Art. Sex. Encycl. Brit., xxi., pp. 720-724.

Gives authorities for influence of nutrition on sex of insect larvæ, tadpoles (Yung, E.), etc. The better nutrition the higher percentage of female forms.

84. ———. Theory of Growth, Reproduction, Sex, and Heredity. P. R. Soc. Edin., 1886, pp. 911-931.

"In determination of sex influences inducing katabolism (deficient nutrition, etc.) tend to result in production of males, as those favouring anabolism similarly to increase the probability of females."

85. Grawitz, P. Beiträge zur systematischen Botanik der pflanzlichen Parasiten, und experimentelle Untersuchungen über die durch sie bedingten Krankheiten. Virchow's Archiv, lxx. (1877), pp. 546-598.

Cited by Krukenberg, an instance of the experimental modification of a fungus.

86. GRUBER, A. Beiträge zur Kenntniss der Physiologie und Biologie der Protozœn. Ber. Freiburg Ges. I., Heft ii., 1886. Ann. and Mag. Nat. Hist., xvii., pp. 473-494.

Spontaneous division occurs at optimum of growth, or in rapid succession with diminution of size in unfavourable conditions.

87. HOFFMANN, H. Ueber Sexualität. Botan. Zeitung, 1885, Nos. 10, 11.

Inter alia, connection between deficient nutrition and maleness.

88. ———————. Vererbung erworbener Eigenschaften. Biol. Centblt., vii., 21 (1887), p. 667.

89. ———————. Kulturversuchen über Variation im Pflanzenreiche (1855-87). Botan. Zeitg., 1887, pp. 260, 772, 773.

Minus nutrition alters flower of Papaver, Nigella, Lamium, etc., and change is transmitted. Nutritive changes hereditarily affect root of *Daucus carota*, and period of blossoming of *Solidago*, etc.

90. JAWOROWSKI, A. Multiplication endogène des cellules. Arch. slav. Biol., i. (1886), pp. 641-651.

Pædogenesis due to rupture of incompletely developed ovarian membrane and the liberation of ovules into the body-cavity, where, in richly nutritive environment, they are

94. Leuckart, R. Die Parasiten des Menschen. Vol. i. translated by W. E. Hoyle. *Cf.* Art. Parasitism (P. Geddes), Encycl. Brit.

Ectoparasites experience mechanical influence in motion of host; physical, in warmth of host; transportation to different medium; and chemical influences from abundant food and exhalations.

Endoparasites experience mechanical influence from peristalsis, confined space, relative absence of currents; physical in darkness, incubatory warmth, etc.; chemical from moisture, abundant rich nutrition, gases, gastric juice, etc. Also the influence on hosts.

95. Macé. L'hétérogamie de *l'Ascaris dactyluris*. Comptes Rendus, ciii. (1887), pp. 306-308.

In *Ascaris dactyluris* young develop and mature within mother at expense of her tissues, and are without exception females. (Anabolic conditions favouring femaleness.)

96. Maupas, E. Sur la multiplication de la *Leucophrys patula*. Comptes Rendus, ciii., pp. 1270-1273.

Relation between varying nutrition and modes of reproduction.

97. ———. Réponse à M. Balbiani à propos de la *Leucophrys patula*. Comptes Rendus, civ. (1887), pp. 308-310.

In *Leucophrys*, with abundant food, fission; with scanty food, metamorphosis without encystation, followed by six successive divisions which have for their end conjugation.

98. ———. Sur la puissance de multiplication des Infusoires ciliés. Comptes Rendus, civ. (1887), pp. 1006-1008.

Reproductive power of Ciliata depends, (1.) on the quality and quantity of the food; (2.) on the temperature; (3.) on the alimentary adaptation of the buccal organs. With a vegetarian diet, the rate of reproduction is much less, and the size smaller.

99. Morini, F. Ancora sulla questione della sessualità nelle Ustilaginee. Mem. Accad. Sci. Bologna, vi., 2 (1885), pp. 283-290.

Deficient nutrition, a condition of conjugation of conidia of Ustilagineæ.

100. Platner, G. Zur Bildung der Geschlechtsprodukte bei Pulmonaten. Arch. mikr. Anat., xxvi., pp. 599-621, 2 pls.

The rapid growth of the ova in hermaphrodite duct of Arion is the natural result of the direct supply of abundant food ensured by their peripheral position.

101. Poulton, E. B. Notes upon Lepidopterous larvæ, etc. Tr. Entom. Soc., 1887, Part iii., pp. 281-321.

Relation between phytophagous larvæ and various species of food-plant. Origin of Carnivorous habits. (Light-seeking, appreciation of gravitation, etc.)

101a. Rolph, W. H. Biologische Probleme. Leipzig, 1884. p. 238.

Relation of nutrition and reproduction (Chaps. iv. and vi.).

102. Seeland, v. (No init.). Über die Nachwirkung der Nahrungsentziehung auf die Ernährung. Biol. Centralblt., vii., pp. 145-158, and four following Nos.

Experiments with fowls, etc.

103. Semper, K. *Op. cit.*

Records abundant instances of influence of food. Influence of parasitic environment (in part nutritive) on parasites.

104. Sutton, J. B. Hypertrophy, its value in Evolution. Proc. Zool. Soc., iii. (1885), pp. 432-445.

108. Yung, E. De l'influence des milieux physico-chimiques sur les êtres vivants. Influence des différentes espèces d'aliments sur le développement de la grenouille (*Rana esculenta*). Arch. Sci. Phys. Nat., vii. (1882), pp. 225-261.

109. *Cf.* Pflüger, E. Über die Geschlechtsbestimmenden Ursachen und die Geschlechtsverhältnisse der Frösche. Arch. f. ges. Physiol., xxix. (1882), p. 13.

110. Zacharias, O. Ergebnisse einer zoologischen Excursus. Zeitschr. f. wiss. Zool., xliii., pp. 271-275, 4 figs.

In spontaneous transverse fission of Planaria, when supply of food abundant (anabolic condition), a new act of fission was to be observed before daughter bud attained the proportions of parent, but if amount of food reduced or altogether withdrawn (katabolic condition), reproduction by fission completely ceased.

111. Zopf, W. Zur Morphologie und Biologie der niederen Pilzthiere (Monadinen), 45 pp., 5 pls. Leipzig, 1885.

With much food ciliated forms (*Pseudospora*) become amœboid (more anabolic); with more abundant food amœboid forms (*Diplophysalis*) become encysted (more anabolic); with deficient food developmental history (*Gymnococcus*) is simplified.

III. Physical.

(*a.*) Heat (112-139).

112. Barfurth, D. Versuche über die Verwandlung der Froschlarven. Arch. Mikr. Anat., xxix. (1887), pp. 1-34, 1 pl.

Reduction of heat retards tadpole metamorphosis.

113. ———. Der Hunger als förderndes Princip in der Natur. Arch. Mikr. Anat., xxvii. (1886), pp. 121-178.

Relation of unfavourable temperature, etc., to sterility.

114. Barthélemy, A. De l'action de la chaleur sur les phénomènes de végétation. Comptes Rendus, xcviii. (1884), pp. 1006, 1007.

Action of heat on roots and heliotropism.

115. Ritzema-Bos, J. Untersuchungen über *Tylenchus devastatrix*. Biol. Centralblt., vii., 21 (1888), pp. 646-659.

Cold, as well as desiccation, may cause latent life.

116. Dallinger, W. H. The President's Address. J. R. Microsc. Soc., ii. (1887), pp. 185-199, 1 pl.

Adaptation of monads, normally flourishing at 65° F. to 158° F. "At certain points in the endurance of cumulative thermal elevations, a distinct physiological change is brought about with greater or less difficulty."

117. Delsaux, E. Sur la réspiration des Chauves-Souris pendant leur sommeil hibernel. Arch. Biol., vii., 1 (1887), pp. 207-215.

Reduction of surrounding temperature lessens the amount of CO_2 produced.

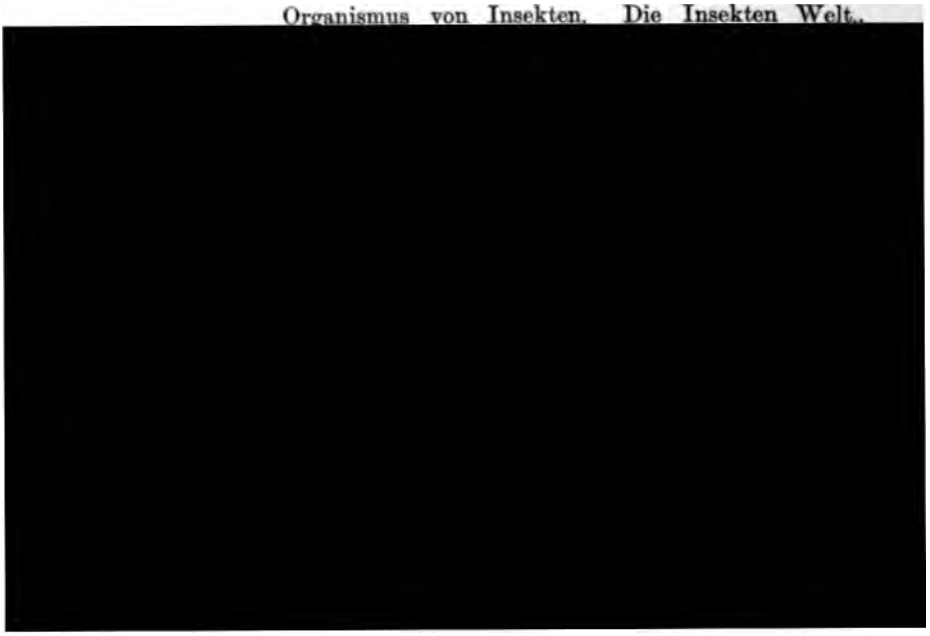
118. Fredericq, L. Sur la régulation de la température chez les animaux à sang chaud. Arch. Biol., iii. (1882), pp. 689-804.

Numerous results and references on the physiological effects of altering temperature.

118A. Frommann, K. See Chemical (45).

Influence of temperature, p. 70; mainly negative results.

119. Gauckler, H. Einfluss hoher Temperaturen auf den Organismus von Insekten. Die Insekten Welt.,



123. Graber, V. Thermische Experimente an der Küchenschabe (*Periplaneta orientalis*). Arch. f. ges. Physiol., xli. (1887), pp. 240-256.

124. Jourdain, S. Blastogénèse. Comptes Rendus, ciii. (1886), pp. 1086-1088.

Buds of *Botrylloides rubrum* at first hermaphrodite; in cold both glands atrophy, female first; in warm weather both completely developed.

125. Koch, G. v. Die Gorgoniden des Golfes von Neapel. Monograph xv., Zool. Stat., Naples.

Influence of warmth, etc., p. 68.

126. Laboulbène, A. Sur l'état larvaire des Helminthes parasites du genre Ascaride. Comptes Rendus, civ. (1887), pp. 1593-1595.

With favourable temperature the embryo of *Ascaris lumbricoides* forms in thirty to forty days; with low temperature and damp atmosphere may be retarded as long as five years.—(Davaine.)

127. List, J. H. Ueber die Variation der Laichzeit bei Labriden. Biol. Centralblt., vii., 2 (1887), p. 64.

According to temperature the spawning period varies more than six weeks.

128. Maupas, E. Sur la puissance de multiplication des Infusoires ciliés. Comptes Rendus, civ. (1887), pp. 1006-1008.

In favourable nutritive conditions *Stylonichia pustulata* divides once in 24 hours at a temperature of 7°-10° C., twice at 10°-15°, thrice at 15°-20°, four times at 20°-24°, and five times at 24°-27° C.

129. Meehan, T. Relation of heat to the sexes of flowers. Proc. Acad. Nat. Sci., Philad. (1884), pp. 111-117.

130. Quinquaud, C. E. De l'action du froid sur l'organisme animal vivant. Comptes Rendus, civ., pp. 1542-1544.

Hyperexcitation, progressive superoxygenation, etc.

131. Rauber, A. (See 22, under I.)

Influence of changes of temperature on embryos of fishes and amphibians.

132. Roedel, H. Ueber die untere Temperaturgrenze bei welcher niedere Thiere noch existiren können. Jen. Zeitschr. Nat., lix. (1886), pp. 183-214.

Graded results of lowered temperature—cessation of function, coma, death, etc.

133. Schlechter. Ueber die Ursachen, welche das Geschlecht bestimmen. Rev. f. Tierheilkunde und Tiersucht. Biol. Centralblt., iv. (1884), pp. 627-629.

Inter alia, influence of season.

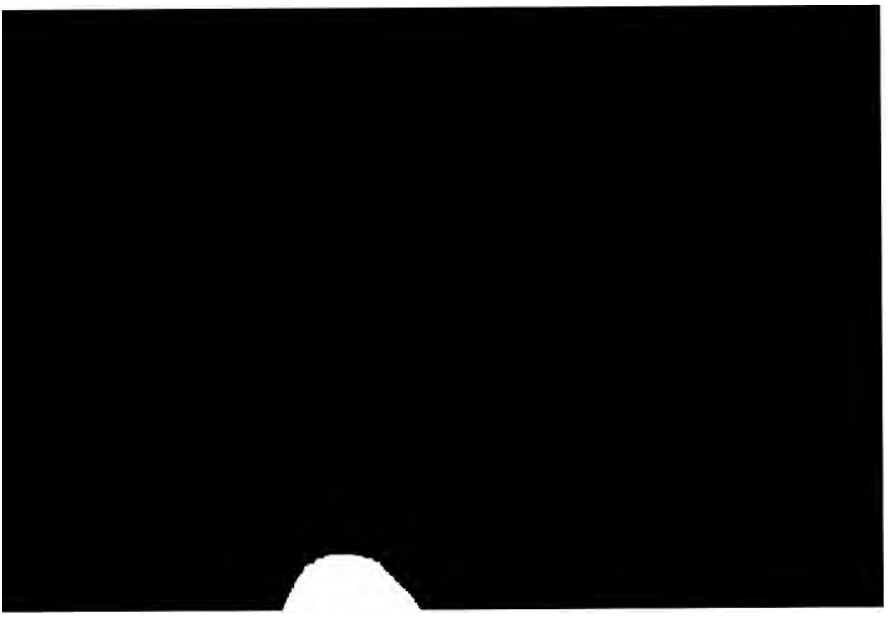
134. Semper, K. *Op. cit.*

Notes how increased heat is associated with quickened contractions of contractile vacuoles of Infusorians, with increased ciliary activity, with size of gills in Artemia (Schmankewitsch), with parthenogenetic reproduction of Aphides, and of Trematodes (Zeller), with more rapid sexual maturity (insects, etc.), with quicker development (Crustacea), etc., etc., and how lessened heat is associated with the converse, with sexual reproduction (Aphides), with dwarf broods, with coma, etc., etc.

135. Strubell, A. Zool. Anz., x. (1887), pp. 42-46, 62-66.

Increased heat shortens larval development of *Heterodera schachtii*.

136. Vines, S. J. *Op. cit.* Influence of temperature, pp. 268, 376, etc.



141. Bert, P. Influence des diverses couleurs sur la végétation. Comptes Rendus, lxxiii. (1871), p. 1444. (*Cf.* Sachs' Physiology of Plants, etc., for summary of similar researches.)

142. Cohn, F. JB. Schles. Ges. Vaterl. Cult., 1883, pp. 179-186. J. R. Micr. Soc., 1884, p. 84.
Mechanical action of light on plants.

143. Detmer, W. Zum Problem der Vererbung. Arch. f. ges. Physiol., xli. (1887), pp. 203-215.
Deep-rooted effect of light on histology of plant organisms (with references).

144. Engelmann, T. W. Über Reizung Contraktilen Protoplasmas durch plötzliche Beleuchtung. Arch. f. ges. Physiol., xix. (1879), pp. 1-7.

145. Fizzoni, G., and Fileti, M. Atti. Accad. Lincei, iv. (1880), p. 168.
Rabbits in dark decreased in weight and amount of hæmoglobin.

146. Fol, H. Sur les conditions d'existence sous le rapport de la lumière, des animaux aquatiques vivant dans les grandes profondeurs. Arch. Sci. Phys. Nat., xiv. (1885), pp. 269-271.

147. Forel, F. A. La pénétration de la lumière dans les lacs d'eau douce. Festschrift. A. v. Kölliker, Bonn, 1887.

148. Frank. Pringsheim's Jahrb. f. wiss. Bot., ix., p. 147.
Influence of light on histology of Thuja. *Cf.* Heinricher, *ibid.*, xv.

149. Geddes, P. Art. Sex. Encycl. Brit. quotes authorities on influence of light on sex.

150. Graber, V. Fundamentalversuche über die Helligkeits-und Farben-Empfindlichkeit augenloser und geblendeter Thiere. SB. Ak. Wien, T. 87 (1883), pp. 201-236.

151. ————. Grundlinien zur Erforschung des Helligkeits und Farbensinnes der Thiere. Prag. und Leipzig, pp. 322, 1884.

152. GRABER, V. Über die Helligkeits-und Farben-empfindlichkeit einiger Meerthiere. SB. Ak. Wiss. Wien, xci. (1885), pp. 129-150.

153. HÉRON-ROYER. Observations comparatives sur le développement externe et l'état adulte des Batraciens du genre Bombinator. Bull. Soc. Zool. Fr., xii. (1887), pp. 640-655, 2 pls.

Quickened the development of larvæ by prolonged (by lamps) conditions of daylight.

154. HERRMANN, L. (See under Electricity.)

Effect of darkness on tadpoles (pp. 418, 419).

155. HIGGINBOTTOM, J. Influence des agents physiques sur le développement, etc. J. de Physiol., ii., p. 625.

156. KRUKENBERG, C. F. W. Vergleichend-Physiologische Vorträge, iii. Grundzüge einer Vergleichenden Physiologie der Farbstoffe und der Farben. Heidelberg, 1884, pp. 85-184.

Effect of light on pigment-forming, p. 90.

157. M'ALDOWIE, A. M. Development and decay of pigment on birds' eggs. J. Anat. Physiol., xx. (1886), pp. 225-237.

Coloration varies in direct ratio to amount of light to which

160. Pick, H. Ueber den Einfluss des Lichts auf die Gestalt und Orientirung der Zellen des Assimilationsgewebes. Bot. Centralblt., xi., Nos. 37, 38, 1 pl.

161. Plateau, F. Récherches sur la perception de la lumière par les Myriopodes aveugles. J. de l'Anat. Physiol., xxii. 3 (1886), p. 431. *Cf.* Comptes Rendus, xcvii. (1883), p. 467.

Abundant references to literature discussing light-seeking and the reverse, and also contraction on exposure to light.

161a. ————. Recherches expérimentales sur la vision chez les Arthropodes. Bull. Acad. Belg., xiv. (1887), pp. 407, 545 ; xv., p. 28.

162. Pouchet, G. De l'influence de la lumière sur les larves des Diptères privées d'organes extérieurs de la vision. Rev. et Mag. de Zool., 1871-72.

163. Poulton, E. B. Colour Relation between Larva of *Smerinthus ocellatus* and its Food-plants. Proc. Roy. Soc., xl. (1886), pp. 135-173. Colour of Pupæ, Trans. Entom. Soc., 1886, pp. 46-48.

The influence of surrounding colour on Lepidopterous larvæ is real, but can only be explained by a complicated physiological and apparently nervous circuit.

164. ————. An Enquiry into the cause and extent of a special Colour-relation between certain exposed Lepidopterous pupæ and the surfaces which immediately surround them. Proc. Roy. Soc., xlii. (1887), pp. 94-108. *Cf.* Proc. Zool. Soc., 1887, pp. 191-274.

165. ————. Further Experiments upon the Colour-relation between Phytophagous Larvæ and their surroundings. Rep. Brit. Ass., 1887, p. 756.

166. Pringsheim, N. Sur l'action de la lumière et la fonction de la chlorophyll dans le plante. Revue Botan., xxvii. (1880), etc.

167. Sachs, J. v. Über den Einfluss der Luftemperatur und des Tageslichts auf das Langenwachsthum. Arb. bot. Inst., Würzburg, 1872.

168. Schneider, R. Ein bleicher Asellus in den Gruben von Freiburg im Erzgebirge. SB. Akad., Berlin, 1887, pp. 723-742, 1 pl.

Tendency of subterranean forms to revert to young or embryonic conditions. (*Cf.* his references to literature of cave fauna.)

169. Schnetzler, J. B. Influence de la lumière sur les larves de Grenouille. Arch. Sci. Phys. et Nat., li. (1874), p. 247.

170. Semper, K. *Op. cit.*

Numerous illustrations of consequences associated with light and darkness.

171. Serrano-Fatigati, E. Influence des diverses couleurs sur le développement et la respiration des Infusoires. Comptes Rendus, lxxxix. (1879), pp. 959, 960.

172. Stahl, E. Ueber den Einfluss des Lichtes auf den Bewegungen der Desmidaceen. Verh. phys. Ges., Wurzburg, xiv., 1879.

173. ———. Ueber den Einfluss der Richtung und Stärke der Beleuchtung auf einige Bewegungserscheinungen im Pflanzenreiche. Ueber den Einfluss der Lichtintensität auf Structur und Anordnung des Assimilationsparenchym. Botan. Zeitung, 1880.

174. ———. Ueber den Einfluss des sonnigen oder schattigen

177. Vines, S. H. Lectures on the Physiology of Plants. Cambridge, 1886.

Influence of Light, pp. 157, 252, 379, etc.

178. Weismann, A. Ueber den Rückschritt in der Natur. Ber. Freiburg Ges., ii. (1887), pp. 1-30.

Refers degenerate eyes in darkness and other similar phenomena to (non) operation of Natural Selection.

179. Wiesner, J. Die heliotropischen Erscheinungen im Pflanzenreich. Denkschr. Akad. Wien, 1878. (See Vines and Sachs, *op. cit.*)

180. Wilhelm, K. Einfluss des Sonnenlichts auf Laubblätter. Biol. Centralblt., iii., 5 (1883), pp. 129-134.

181. Yung, E. De l'influence des différentes couleurs du spectre sur le développement des animaux. Comptes Rendus, liii.-lvii. (1878), pp. 998-1000.

182. ———. De l'influence des lumières colorées sur le développement des animaux. Comptes Rendus, xci. (1880), pp. 440, 441.

Effect of (coloured) light on development.

183. ———. Contributions à l'histoire de l'influence des milieux physiques sur les êtres vivants. Arch. Zool. Exper., vii. (1878), pp. 251-282.

184. ———. Contributions à l'étude de l'influence des milieux physico-chimiques sur les êtres vivants. Archiv de Zool. Exper., T. i. (1883), pp. 31-55.

185. ———. Sur l'influence des lumières colorées sur le développement des animaux. Arch. Sci. Phys. Nat., T. i. (1879), p. 209.

186. ———. De l'influence des lumières colorées sur le développement des animaux. MT. Zool. Stat. Neap., ii. (1881), pp. 233-243.

187. ———. Sur l'influence des milieux physico-chimiques sur le développement des têtards de grenouille (*Rana esculenta*). Arch. Sci. Phys. Nat., x. (1883), pp. 347-349.

188. ———. Report in Ann. Mag. Nat. Hist., xiii. (1884), p. 72.

189. Yung, E. De l'influence des variations du milieu physico-chimique sur le développement des animaux. Arch. Sci. Phys. Nat., T. xiv. (1885), pp. 502-522.

(*c.*) Electrical (190-196).

190. Frommann, K. *Op. cit.*, 45, pp. 50-69, 115-177, 255-275.

191. Hermann, L. Eine Wirkung galvanischer Ströme auf Organismen. Arch. f. ges. Physiol., xxxvii. (1885), pp. 457-460.

192. ————————. Weitere Untersuchungen über das Verhalten der Froschlarven im galvanischer Ströme. Arch. f. ges. Physiol., xxxix. (1886), pp. 414-419.

193. Maggiorani, C. Influenza del magnetisma sulla embriogenesis. Contributo alle ricerche biologiche. Atti Rend. Acc. Rom., vol. i. (1887), pp. 123-143, 1 pl.

194. Roux, W. *Op. cit.*, 26.

Influence of electric stimuli on developing ova.

195. Slater, J. W. Trans. Entom. Soc. London, 1885.

Influence of magnetism upon insect development. (*Cf.* references.)

196. Wollny, E. Ueber die Anwendung der Electricität bei den Pflanzenkultur. Ackermann, München, pp. 37,

tes Rendus, civ. (1887), pp. 1113-1115. Ann. Nat. Hist., xx., pp. 78-80.

Phyxus paguri makes abdominal appendages of male *Eupagurus* like normal female, and testes are filled with imperfect spermatozoa. *Peltogaster paguri* makes male *Pagurus* sterile, and modifies abdominal appendages of female in the direction of the normal male.

199A. KOROTNEFF, A. Zwei neue Cœlenteraten. Zeitschr. f. wiss. Zool., xlv. (1887), pp. 468-490, 1 pl.

200. LEUCKART, R. Die Parasiten des Menschen. Leipzig, 1876, 1881. Vol. i. translated by W. E. Hoyle, Edinb., 1886.

Effects of parasite on host—inflammation, boring, choking, deterioration of juices; also destruction of reproductive organs (*Cuterebra emasculator* in testes of squirrel, Nematodes on pond snails). *Cf.* Semper.

201. LUNDSTRÖM, A. N. Pflanzenbiologische Studien. II. Die Anpassungen der Pflanzen an Thieren. N. Act. Upsala, xiii., 2 (1887), pp. 1-88, 4 pls.

202. ROUX, W. Der Kampf der Theile im Organismus. Leipzig, 1881.

Illustration of histological modification induced by parasites.

203. SCHULZE, F. E. "Challenger" Report on Hexactinellida 1887.

Commensal polypes (*Stephoscyphus mirabilis*) have wholly altered the form of a sponge (*Myxilla*).

204. SEMPER, K. *Op. cit.*

Records how sponges are modified by polypes; Hydroids by Pycnogonidæ, till a specific character; the modifying association of Buccinum and a Gorgonia, an Antipathes and an Annelid; quotes Kossmann to show that asymmetrical growth of parasitic Pachybdella, originally induced by pressure, but now hereditary. Also mechanical influence of parasites.

205. Botanical works, for illustrations of direct modification of flower shape by insect visitors, of extra-floral nectaries (Beccari) now hereditary, but originally due to ant-punctures, of malformations in leaves which become constant characters.

Addenda to General List.

(206-222.)

206. Dall, W. H. Deep-Sea Mollusca. Bull. Mus. Comp. Zool., xii. (1886), pp. 171-318, 9 pls.

207. Edwards, F. W. De l'influence des agents physiques sur la vie. Paris, 1824.

Inter alia, effect of nutritive changes on frogs (quoted by Yung).

208. Fontannes, M. Sur certaines corrélations entre les modifications qu'éprouvent des espèces différents, soumises aux même influences. Comptes Rendus, ciii. (1886), pp. 1022-1024.

209. Fuchs, T. Was haben wir unter der "Tiefsee-fauna" zu verstehen, und durch welches physicalische moment wird das Auftreten derselben bedingt. Verh. Geol. Reichanst., Wien, 1882.

210. Gautier, A. Du mécanisme de la variation des êtres vivants. Hommage à M. Chevreul, Paris (1886), pp. 29-52.

Constancy of a form is "nothing more than the resultant of the forces which maintain the *chemical species* of which the organism is composed. The condition of variation, or of individualisation, is, on the contrary, the more or

214. Meehan, T. On parallelism in Distinct Lines of Evolution. P. Acad., Philadelphia (1886), pp. 294, 295.

"Environment seems to have no further influence than to incite to action a change already ripe for development."

215. Mer, E. Bull. Soc. Bot., France, xxix., 1881. *Ibid.*, 2d Ser., viii. (1886), p. 168.

Influence of environment on water plants.

216. Mühlberg. Die Allgemeine Existenzbedingungen der Organismen. Aaran. Sauerlander, 1882.

Simply general discussion.

217. Münsterberg, H. Die Lehre von der natürlichen Anpassung in ihrer Entwicklung, Anwendung, und Bedeutung. Inaug. Diss. Leipzig, 1886, pp. 114.

218. Noll (no init.). Über den Einfluss äusserer Kräfte auf die Gestaltung der Pflanzen. Biol. Centralblt., vii., pp. 699-701. 60 Ners. Deutsch. Naturf.

Discussing plants, Protozoa, protoplasmic layers, etc., in relation to environment.

219. Preyer, W. Über die allgemeinen Lebensbedingungen. Naturwissenschaftliche Thatsachen und Probleme. Berlin, 1880.

220. ———. Die Bewegungen der Seesterne. MT. z. Stat. Neap., vii. (1887), pp. 191-233, 1 pl.

Various effects of mechanical, electrical, thermal, and chemical stimuli. Attraction of Asterids to light. Sensitiveness to chemical constitution of the sea-water.

221. Roux, W. Beiträge zur Morphologie der functionellen Anpassung. Arch. de l'Anat. Physiol., 1882, p. 76-162.

221a. ———. Beiträge zur Morphologie der functionellen Anpassung. Über die Selbstregulation der morphologischen Länge der Skeletmuskeln. Jen. Zeitschr. f. Naturw., xvi. (1882), pp. 358-427.

Good example of working out of a set of "functional variations."

222. ———. Zur Mechanik der Entwickelung. Zeitschr. f. Biol., xxi. (1886), pp. 1-118.

Self-differentiation and correlative differentiation.

Environmental Influence in relation to Heredity.

Some recent works bearing on this subject (223-246).

223. Bambeke, C. van. Pourquoi nous ressemblons à nos parents. Bull. Acad. roy. Belg., T. x. (1885), No. 12.

224. Barfurth, D. Biologie der Forellen. Arch. mikr. Anat., xxvii., pp. 128-178, 2 pls.

Influence of hindered spawning (from nature of surroundings) not confined to modifying ovary, but the elements afterwards produced result in degenerate trouts.

225. Berthold, G. Studien über Protoplasma-mechanik. Leipzig, 1886, p. 332, 7 pls.

The connection between generations is effected by the chemical continuity of the constituent substances, and by the definite morphological composition of the reproductive elements.

226. Brooks, W. K. The Law of Heredity. Baltimore, 1883.

The relation between change of environment and throwing off of gemmules.

227. Detmer, W. Zum Problem der Vererbung. Archiv f. d. ges. Physiol. (Pflüger), xli., 5, 6 (1887), pp. 203-215.

Against Weismann.

228. Eimer, G. H. T. Die Enstehung der Arten auf Grund von

233. Hoffmann, H. Vererbung erworbener Eigenschaften. Biol. Centlblt., vii., 21 (1888), p. 667. Botan. Zeitung (1887), pp. 260, 772.

Instances of the transmission of characters impressed upon the plant by nutritive environment.

234. Kollmann, J. Biol. Centralblt., v. (1886), pp. 673-679, 705-710.

Critique of Weismann and Virchow.

235. Orth, J. Über die Enstehung und Vererbung individueller Eigenschaften. Festschrift A. v. Kölliker, 1887.

236. Richter, W. Zur Theorie von der Kontinuität des Keimplasmas. Biol. Centralblt., vii., 2, 3, 4.

Historical and critical, supporting Weismann.

236a. ———. Zur Vererbung erworbener Eigenschaften. Biol. Centralblt., vii., 22 (1888).

237. Roth, E. Die Thatsachen der Vererbung in Geschichtlicher-Kritischer Darstellung. 2d Ed., Berlin, 1885.

Bibliographic list up to 1876.

238. Sedgwick, A. Development of Cape species of Peripatus. Q. J. Micr. Sci., xxvi., pp. 175-207, 3 pls.

Primitive syncytial character of embryo.

239. Semper, K. *Op. cit.* Appendix, p. 410.

Note on the hereditary transmission of characters impressed on the organism by the environment.

240. Virchow, R. Descendenz und Pathologie. Virchow's Archiv, ciii. (1886), pp. 1-15, 205-215, 413-437.

Critique of Weismann's theory of the non-inheritance of characters externally impressed during individual life of the parent.

241. ———. Acclimatisation. 58 Vers. Naturf. u. Eerzte, 1886.

242. Weismann, A. Die Continuität des Keimplasmas als Grundlage einer Theorie der Vererbung. Jena, 8vo (1885), pp. 122.

243. ———. Zur Annahme einer Continuität des Keimplasmas. Ber. Freiburg Ges., Bd. i., Heft 4 (1886).

244. Weismann, A. Die Bedeutung der sexuellen Fortpflanzung für die Selektions-Theorie. Jena, 1886, etc. *Cf.* former works.

Individual peculiarities impressed by environmental influences on the Metazoan parent are not known to be hereditarily transmitted.

245. ———————. Zur Frage nach der Vererbung erworbener Eigenschaften. Biol. Centralblt., vi., 2, 1886.

246. Ziegler, E. Können erworbene pathologische Eigenschaften vererbt werden und wie enstehen erbliche Krankheiten und Missbildungen. Jena, 1886.

Corroboration of Weismann.

Some General Works.

(247-261.)

N.B.—Many other classic works on Evolution of course discuss the Buffonian position, and might equally have been cited.

247. Claude Bernard. Phénomènes de la vie communs aux animaux et aux végétaux, 1870-1878.

248. Buffon. Histoire naturelle générale. Paris, 1749.

249. Chambers, R. Vestiges of the Natural History of Creation.

257. Herbert Spencer. The Factors of Organic Evolution. *Nineteenth Century*, No. 86, 1886. Kosmos, xvii. Separately—Williams & Norgate, 1886. *Cf. The Leader*, 1852; Principles of Biology, 1859.

258. Geoffroy St Hilaire. Principes de Philosophie zoologique. Paris, 1830.

259. Treviranus, G. R. Biologie, oder Philosophie der lebenden Natur, Pt. i. Göttingen, 1802. Erscheinungen und Gesetze des Organischen Lebens, 1831.

Interprets almost all in terms of environmental influence.

260. Wallace, A. R. Contributions to the Theory of Natural Selection, 1871, etc. The Origin of Species and Genera. *Nineteenth Century*, vii., 1880.

261. Weismann, A. Studies in the Theory of Descent. Meldola's Trans., 1880-1882.

XXXIX. *On the Prevalence of Eurypterid Remains in the Carboniferous Shales of Scotland.* By James Bennie, Esq., of the Geological Survey of Scotland.

(Read 21st March 1888.)

In this paper it is intended to put upon record some facts about the Eurypterids which I have become acquainted with in my researches for spores among the coals and shales of the Carboniferous formation. These facts seem to me to prove that individuals of that family were not rare, as the few instances of their occurrence on record suggest, but extremely abundant—certainly as to individuals, and probably much varied as to species—during the whole of the Carboniferous period. The extreme paucity of the record as to individuals and species is well shown in a paper by Dr Woodward in the *Geological Magazine* for November last, wherein he enumerates five species, represented by seven specimens, which he says is complete for the Devonian and Carboniferous formations. To Dr Woodward's list must be added another species—*Eurypterus Stevensonii*—described by

R. Etheridge, jun. (*Quart. Journ. Geol. Soc.* for May 1881, xxxiii., 222), from specimens obtained in the Lower Carboniferous formation of Berwickshire. The remains indicated, in Mr Etheridge's opinion, a much larger species than *E. Scouleri*. The specimens from which *E. Stevensonii* was described were from the collections of the Geological Survey of Scotland, of Mr Stevenson of Duns, and of Mr Smith of Preston farm, Duns. Mr Etheridge supposed that some of the specimens might not be body rings or segments, but portions of the limbs or appendages: this has been settled by Mr Peach joining two of these fragments together, when its character as a limb was manifest. There is exhibited in the Museum of Science and Art, Edinburgh, a head (with several of the body rings attached) of *E. Scouleri* from East Kirkton quarry, Bathgate, which, having the black dormal covering with the peculiar ornamentation of the family preserved as in life, ought to be figured, as the original specimen described by Dr Scouler, now in the Andersonian Museum, Glasgow, is decorticated, and only the internal cast of the head preserved. Another specimen of a new and undescribed Eurypterid was found by, and is in the possession of, Mr Robert Dunlop of Whiterigg, Airdrie. Its chief distinction seems to be that the body segments are extremely narrow and ribbon-like.

With these preliminary remarks I come to the facts which

Radstock, Somersetshire, where the head of the Eurypterid lately described by Mr Peach was found.

It will be most convenient to give these occurrences in two groups, arranged according to the materials in which the remains were found.

First Group, in black fakes—(1.) Hailes Quarry, 4 miles S. of Edinburgh; (2.) Kingscavil Quarry, 1 mile E. of Linlithgow; (3.) Whinnyhall Old Quarry, 1 mile N.E. of Burntisland; (4.) Gilmerton Sandstone Quarry, 4 miles S. of Edinburgh; (5.) Cove shore, 1 mile N.E. of Cockburnspath.

Second Group, in fireclays or plant-beds—(1.) Joppa Quarry, 3 miles E. of Edinburgh; (2.) Shear Burn, 3 miles S. of West Calder; (3.) Shore West of the Pans, 1 mile E. of Crail, Fife.

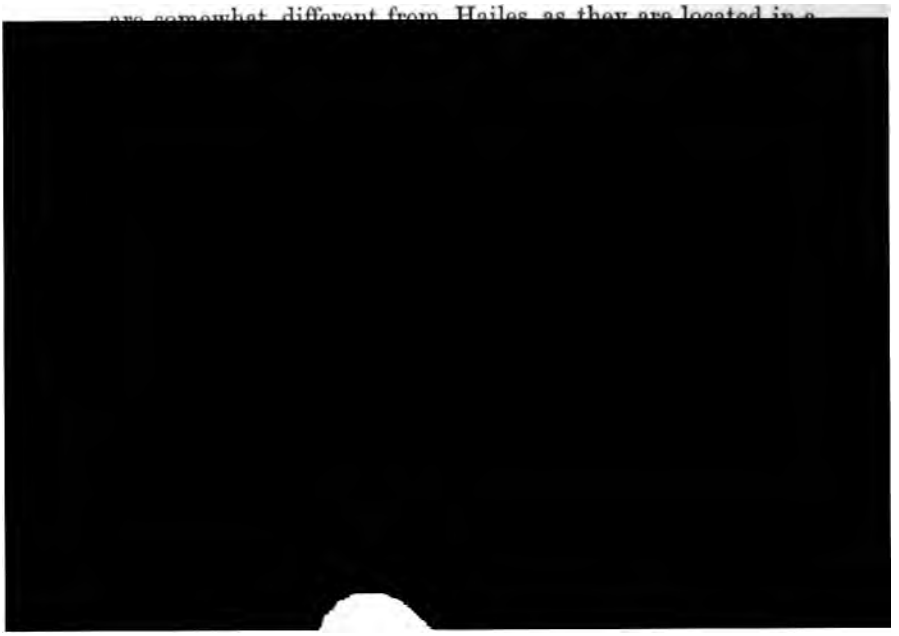
The positions of Nos. 1, 2, 3, and 5 are in the Calciferous Sandstones, and No. 4 in the Carboniferous Limestone. In the second group the position of No. 1 is in the Carboniferous Limestone, and Nos. 2 and 3 in the Calciferous Sandstones.

First Group in Black Fakes.

(1.) *Hailes Quarry.*—At page 104 of the paper on Spores it is stated that a considerable number of pieces of scorpion and Eurypterid skin had been found in the black fakes which occur in the sandstone of Hailes quarry. Since the time when that statement was made larger quantities of these fakes have been examined and the results multiplied manifold, and the conclusions confirmed with increased emphasis. Throughout the whole time during which the 200 feet or so of the sandstone of Hailes was being deposited, the winds must have wafted and the streams have floated into the broad shallow lake in which the sand was deposited all the light vegetable and animal *débris* off the land that they could lift and carry. This *débris*, after floating for a time, sank and was buried in the sandbed as it fell, or as the waves disposed it. This would be most frequently in small patches, which now exist as black streaks in the solid layers of sandstone; less frequently in thin layers, which now form the partings by which the sandstone is divided into the shallow beds, which is the most characteristic feature of the Hailes sandstone; and sometimes into beds of black and white fakes,

consisting now of alternate laminæ of carbonaceous matter and sandstone often not thicker than sheets of stout paper. These fakes, being useless as building stones, are thrown aside as waste, and when thoroughly weathered the white layers can be easily separated from the black, which latter when crushed resolve into spores, sacs, bits of plant stems, crumbs of carbonised wood, and shreds of scorpion and Eurypterid skin. As I have not yet found time or patience to count how many pieces of Eurypterid skin turned up in any given quantity of material, I cannot give the number with the precision of a census enumeration, but as these pieces amount to many hundreds, we may, without exaggeration, say they represent one hundred individuals. But then as the amount of material from which they were taken compared with the amount that remains in the rock is infinitesimal, we may safely conclude that each hundred pieces got may be represented by a thousand pieces locked up in the solid stone which it is impossible to extract. These facts, I think, prove without any gainsaying how numerous the Eurypterids must have been in that portion of the carboniferous land represented by the sandstone of Hailes quarry.

(2.) *Kingscavil Quarry*, 1 mile E. of Linlithgow.—The conditions under which the black fakes of Kingscavil occur are somewhat different from Hailes, as they are located in a



been found in the black fakes in Kingscavil. Unlike Hailes, however, there was a commingling of the present life with the Carboniferous life of Kingscavil, which made the search more complex, yet added much to the dramatic interest of the work. Some of the walls built of black fakes faced the south, and afforded sunny spots where the flies and other insects might enjoy the warmth of noontide. The spiders—the scorpions of the present day in Kingscavil—spread their webs across the interstices between the slabs and caught the denizens of the air, and, having devoured the soft parts of their bodies, left their wings and harder parts strewn about the precincts of their dens. These were lifted indiscriminately by my resurrectionary trowel, and of course invariably turned up in the prepared material with the fragments of scorpions and Eurypterids, and thus the past and present life in Kingscavil was strangely blended in a resurrection common to both. Repeatedly in searching I lifted now an insect's head or wing or leg, and then a bit of scorpion or Eurypterid; now a seed of some plant still growing, and then a spore or sac of some carboniferous tree—the past and present being before me, making me contemporary with both.

(3.) *Whinnyhall Old Quarry*, 1 mile N.E. of Burntisland.—In this quarry the black fakes occur in somewhat different conditions than obtain in Hailes or Kingscavil, as not only are they found between laminæ of sandstone, but also in thin layers of blaes, an inch or so in thickness dividing thin beds of sandstone 3 or 4 inches in thickness. Under about 40 inches of a coarse barren sandstone there is at Whinnyhall old quarry 12 or 14 feet of thin beds of sandstone parted by layers of blaes. These partings of blaes when thrown aside weather into dust, and can be gathered and washed as easily as limestone shale. The spores and pieces of scorpion skin are much better preserved in blaes than in sandy fakes, as in the blaes there are none of the grains of sand or flakes of mica which deface by minute pitting the spores or skins found in sandy fakes. The ornamentation of the spores or skin are therefore much better preserved, and are often as perfect as in life. The yield of scorpion remains exceeded here those of the Eurypterids, still enough of the latter were

got to prove that here also they were prevalent in this position, which is but a short distance above the Grange or Burdiehouse limestone.

(4.) *Gilmerton Sandstone Quarry.*—In this quarry also the black fakes are got chiefly in the beds of blaes 2 or 3 feet in thickness, which separate the thick beds of sandstone. The spores and scorpion and Eurypterid remains are therefore as good as those from Whinnyhall; indeed, the Eurypterid remains are, if possible, better preserved and more numerous in this position, which is just above that of the Gilmerton limestone.

(5.) *Cove Shore*, 1 mile N.E. of Cockburnspath.—This is perhaps the best example of Eurypterid and scorpion remains in black fakes that we have. Its position is but a few feet above rocks which are considered to be the Upper Old Red Sandstone, and consequently at the very base of the Carboniferous formation. The fakes are in two layers, respectively 12 and 18 inches, with a band of sandstone 4 inches, in which are plant-stems, and are immediately overlaid by a bed of sandstone 18 inches in thickness, crowded with narrow stems of calamitis and lepidodendroids, generally as casts and impressions, but sometimes solid with the woody structure preserved. It was in this upper bed that *Cycadites Caledonicus* was found, which Mr Salter sup-

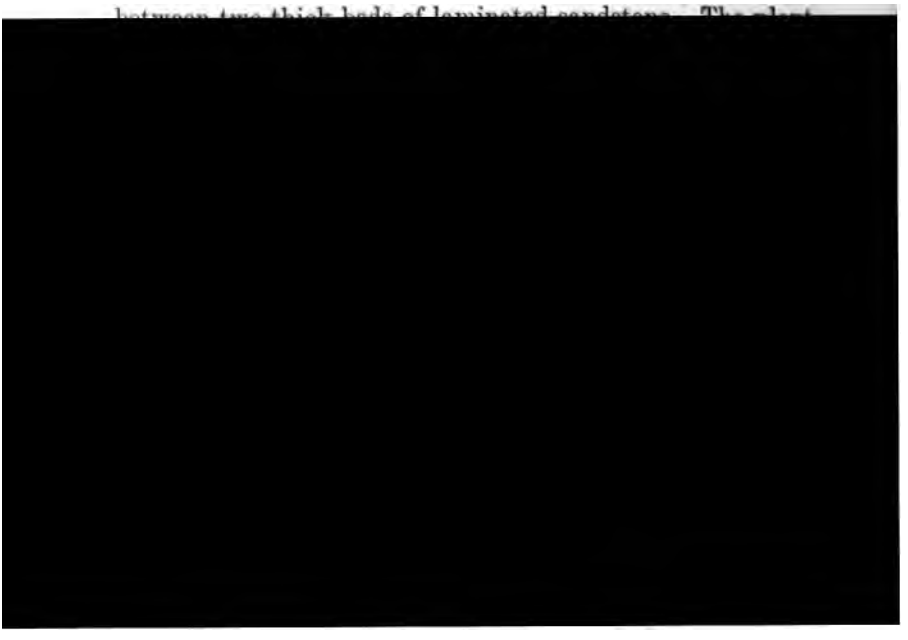
SECOND GROUP IN FIRECLAYS AND PLANT-BEDS.

(1.) *Joppa Quarry*, 3 miles E. of Edinburgh.—The two positions in this quarry are the most important in this group. These are about 100 feet apart vertically, and are both fireclays beneath small coals each 3 inches in thickness. The lower one lies about a foot below the Joppa limestone, which is well known to be the lowermost of the Upper Limestones, and underneath it lie the valuable seams known as the Edge coals of Midlothian. The section may be detailed—Joppa limestone in two beds, 4 feet; shale, 1 foot; coal, 3 inches; shale and fireclay, 6 inches; then a thick bed of sandstone, the surface of which immediately under the fireclay is traversed by numerous roots and rootlets of *Stigmaria*. The first 3 inches under the coal is in parts a shale rather than a fireclay, and has in it numerous shreds of the epidermal tissue of plants in a mummified condition, many of which are translucent, and show the structure as well as in recent plants. In many of these shreds the stomata or breathing pores are distinctly visible. A good number of spores occur among the vegetable *débris*, a few shreds of scorpion skin, and a great many pieces of Eurypterid skin with all the markings which distinguish the family nearly as perfect as when in life. There is evidence that much of the vegetable *débris* and also the Eurypterid fragments which the wind wafted about were limed by the waters in the little pools on the surface of an old soil, and when over-saturated sank and were buried with the dust that the same winds carried into the pools from the land surface immediately surrounding. The next position in Joppa quarry is situated in the eastmost face, and the bed they lie in consists of 3 inches of fireclay below 3 inches of coal, and has yielded hundreds of pieces of Eurypterid skin. They are all in exceedingly good condition, with the peculiar ornamentation, the "hall mark" of the family, as emphatically embossed as we see in minted coin or medals.

(2.) *Shear Burn*, near Harburn Tile Works, 3 miles S. of West Calder.—Beneath a 2-inch coal occurs a layer of fireclay equally thin, which has yielded for its thickness an

extra number of pieces of scorpion and Eurypterid skin, excellently preserved, with all the peculiarities of structure and ornament which distinguish the two families. This coal is the middle one of three, which occur in a bed of fireclay or shale 8 or 10 feet in thickness which lies between two beds of sandstone, the lower of which overlies a thick bed of volcanic ash. The fireclays represent old soils, and the coals the plants which grew therein, and the pieces of scorpion and Eurypterid skin the animals that lived and hunted for prey beneath their shade. The numbers of these animals may be roughly guessed from the fact that from a small bagful cut out from the outcrop, in cubic bulk not more than half a cubic foot, several dozen pieces of Eurypterid skin were derived. If so small a portion of the bed yielded so many, then the quantity in the whole must be incalculable by any ordinary enumeration, and can be only expressed by some of these figures of speech, such as the hairs of the head, expressive of multitudes which no man can number. The strata exposed in Shear Burn must lie deep down in the Calciferous Sandstones.

(3.) *Shore West of the Pans*, 1 mile W. of Crail, Fife.—The remains of scorpions occur here in a plant-bed in the middle of a thick bed of clayey shale which intervenes



of sand and mud, the pauses in the deposition being just sufficient to allow each film of sand or mud to harden ere the next was laid down upon it.

The position of this plant-bed has been definitely fixed by Mr Kirkby having identified a limestone which lies a few feet below it as the equivalent of one which occurs at Bellow Ness, west of Anstruther, the position of which Mr Kirkby has found by actual measurement to be 3135 feet below the St Monans Limestone—the Fife equivalent of the Hurlet Limestone. It is thus certain that the Eurypterids, at a very early period, were abroad in the east of Fife in considerable numbers.

From the foregoing facts the following conclusions may be safely inferred:—

1*st*, That there cannot be any reasonable doubt that individuals of the family of Eurypterids were extremely abundant during the Carboniferous period in the places and positions detailed.

2*d*, That as all the pieces of Eurypterid skin are profusely sculptured or, more correctly, embossed with various patterns representing lozenges, crescents, round dots, crimpings of the skin, or projections of it into hair-like bristles, the idea of a variety of species is suggested, and would be entertained were we sure that a change of style of ornament was not merely indicative of different parts of the body of the same individual. It is, therefore, much to be desired that a whole Eurypterid might be captured anywhere, and the ornament of the head, the body, the limbs, or the tail figured and described, so that we might know whether a difference of pattern was individual or specific. Till that is done we must content ourselves with the conjecture that variety of design may mark distinctions of species.

3*d*, From the almost invariable occurrence of Eurypterid with scorpion remains, showing that they were companions in life as they are now neighbours in death, we may infer there was not in Carboniferous times any great essential difference in their economy or habits, seeing there was none in their habitats. In some localities, such as Hailes and Kingscavil, the conditions indicate burial in sediment, but

those of Shear Burn and many others like it, especially those in Joppa quarry, where the remains of both were buried in dust in an old vegetable soil, we are forced to think of both as breathers of air, and that the Carboniferous Eurypterids, like the ancient and the recent scorpions, were Arachnids, living in the air and on dry land.

4th, That, as a rule, the places where Eurypterids ought to be sought are plant-beds and black flakes, and that, while the latter are sure to yield fragments, in the former whole Eurypterids may also be found—a hint by which I hope our friends who search for fossil plants may profit, and, like Mr Kidston, give us the benefit of their finds, by getting Mr Peach to describe them as he has lately so admirably done the small head from Radstock.

ADDENDA.—As further proofs of the prevalence of Eurypterids in carboniferous strata, and also as a directory to those who may wish to search for Eurypterids, I may here give some fugitive occurrences which are known to me from books or collections.

1. *East Kirkton Quarry, Bathgate.*—The original locality from which the specimen described by Dr Scouler as *Eidothea* was obtained. In all five heads are said to have been got from this place. (*See* Hibbert's paper in *Trans. Roy. Soc. Edinb.* xiii. p. 234, and Woodward's Monographs, *Pal. Soc.*,

basso-relievo markings on adjoining part, exhibited in Museum of Science and Art, Edinburgh.

6. *Shore West of Dunbar.*—In red and green shales a leg of Eurypterid was found by the Survey collector. In collection of Geological Survey of Scotland.

7. Several narrow body segments of an Eurypterid in collection of R. Dunlop, Whiterigg, obtained from the Coal-measures of the neighbourhood.

8. *Hailes Quarry.*—From the black bituminous shale above the sandstone, obtained by Dr Macfarlane of the Botanic Gardens during the last tirring of that shale in 1878, shown to me by C. W. Peach, to whom it had been sent for determination.

9. *Left Bank of the Water of Leith, between Redhall Mill and Colinton Tunnel* in the cutting of Balerno Railway.—A large piece of Eurypterid skin was found by the Survey collector. It was remarkable from spine-like projections all over the surface. Collection of the Survey of Scotland.

10. *Shore at Methil, Fife.*—A small portion of Eurypterid found by J. W. Kirkby, and determined by Dr Woodward. Obtained from the red beds above the Coal-measures of Fife. This is the highest position in which Eurypterid remains have been found in Scotland.

11. Fragments of Eurypterid described by Sir W. Dawson as the skin of one of the reptiles whose bones and teeth were found in a tree-stump—shown by Mr Peach to be Eurypterid at page 443 of this volume.

12. *Calderwood Cement Stone, East Kilbride.*—Piece of Eurypterid skin well marked, with embossed crescents. Collection of J. Coutts, now in Museum of Science and Art, Edinburgh.

13. *Banks of the River Tweed at Lennel Braes.*—Portion of Eurypterid skin described and figured by Mr Peach in *Trans. Roy. Soc. Edinb.*, xxx., 523.

14. *Hunterian Museum College, Glasgow.*—Several pieces of Eurypterid skin from Kimmerghame Quarry, Berwickshire, presented by Mr Stevenson of Duns; probably parts of *E. Stevensonii.*

XL. *On the Fructification of two Coal-measure Ferns.* By Robert Kidston, F.R.S.E., F.G.S. [Plate XXI.]

(Read 18th April 1888.)

Crossotheca, Zeiller, 1883.

Crossotheca, Zeiller, Ann. d. Sc. Nat., 6e sér., Bot., vol. xvi., p. 180; id., Flore foss. d. bassin houil. d. Valenciennes, p. 33, fig. 21.

Sorotheca, Stur, Zur Morph. u. Syst. d. Culm- u. Carbon-Farne, p. 175; id., Carbon-Flora, i., p. 273.

Soroclatus, Lesquereux (in part), Coal Flora, vol. i., p. 327.

Description.—Fertile and barren pinnules dissimilar, the fertile pinnules having the limb much reduced. Sporangia exannulate, tapering to a point at the apex, contiguous, more or less united among themselves, and suspended like a fringe from the margin of the fertile pinnule.

Remarks.—This genus has been described and illustrated by Zeiller in the Ann. d. Sc. Nat. (*l. c.*) and in his "Flore foss. d. bassin houil. d. Valenciennes." In this latter work he gives additional and fuller figures of *Crossotheca Crepini*, Zeiller,[1] the type of the genus, and also figures a second species, *Crossotheca Boulayi*, Zeiller.[2]

The name of *Sorotheca* has been applied to the same plants by Stur; but his paper containing the description of his

[redacted]

in the direction of their axis. The sporangia are placed close together, and it is difficult to determine whether they are free or united to each other. According to Zeiller they appear to be united in pairs or perhaps in fours at the extremities of veins which are given off from a swelling of the pedicel that terminates in a thickening in the centre of the fertile pinnule.

It should be mentioned that what are here treated as exannulate sporangia are regarded by Stur as portions of an indusium which has burst at maturity into valves. This view, however, appears to be entirely at variance with the structure of the organs under consideration.

Among fossil genera *Crossotheca* approaches most closely to *Calymmatotheca;* but in the latter genus the sporangia are not attached around the margin of a prominent disc, nor are they so fully united to each other. In *Calymmatotheca* the branches bearing them are also entirely deprived of foliage-pinnules, and ramify by a series of dichotomies; and, as far as observation has shown, the fruiting pinnæ are only borne at the base of the frond.

Crossotheca fimbriata, Kidston, n. s.
(Pl. XXI., Figs. 1-8.)

Description.—Frond tripinnate, pinnæ deltoid, subalternate. Fertile and barren pinnæ dissimilar. Fertile pinnules simple, with the limb much modified; sporangia exannulate, linear, numerous, united to each other and suspended from a central disk, which is borne at the summit of a slender pedicel. Barren pinnules divided into from two to seven single-veined, simple or bifid, linear segments, according to their position on the pinna.

Remarks.—The specimens of *Crossotheca fimbriata* which I have the pleasure of describing were communicated to me by Mr Walter Hemingway, to whom my thanks are due for the opportunity of examining this interesting addition to the Coal-measure flora of Britain.

Figs. 1-3 show portions of what are probably primary pinnæ; at the right of the pinna in fig. 1 is a small fragment

of a rachis, to which probably the fruiting pinna was attached.

The sporangia are borne as a fringe at the margin of what appears to have been an oval disk. This disk and, more particularly, the sporangia appear to have possessed a considerable thickness of tissue, which contrasts markedly with the delicate structure of the barren pinnules. The sporangia are converted into a bright, brittle, carbonaceous substance, so that in splitting the stone in almost all cases they are more or less fractured; and, further, in no case where they are at all well preserved have I been able to discover a complete fruiting pinnule, one-half of each pinnule having apparently adhered to each side of the matrix when the stone was split. Thus there is only one-half of the disk with its surrounding fringe of sporangia shown on the fossils and their counterparts respectively.

Figs. 4 and 5 represent each two fruiting pinnules, magnified six and a half times. These figures are drawn under the microscope with the camera lucida, and every endeavour has been taken to avoid any "restoration;" so that those who cannot see the originals may form their own conclusions from the drawings.

Fig. 4 is an enlargement of the two fruiting pinnules marked *a* in fig. 1. Both these pinnules, as already men-

peltate attachment of the fruiting pinnules to the pedicels is therefore probably caused by the pinnule *lying upon* the pedicel and concealing the upper part of it.

Fig. 5 exhibits very much the same characters as fig. 4.

Fig. 6 shows four sporangia, enlarged eighteen times. The form of the sporangia is better shown here than in the previous figures. This figure is part of the fruiting pinnule marked *b* in fig. 1. The sporangia are linear and apparently blunt-pointed, as shown by that to the left; the other three are probably broken over at their apices. They all show, especially those to the left, an apparent basal contraction which ends in a short pedicel. The sporangia are clearly united to each other and only free at the apex. For the purpose of comparison I have given a copy of a fruiting pinnule of *Crossotheca Crepini*, as figured by Zeiller (fig. 9).

The barren pinnules of *Crossotheca fimbriata* are of very delicate texture, and though they frequently occur on the same slabs as the fruiting specimens they are seldom well preserved. Two fragments are shown in figs. 7 and 8. Barren pinnæ have been observed attached to the same rachis as the fruiting pinnæ, and in one case one of these fruiting pinnæ has a few barren pinnules interspersed with the fruiting ones.

Crossotheca fimbriata in the barren condition seems undistinguishable from *Calymmatotheca schatzlarensis*, Stur.[1] The figures given by Stur are somewhat indistinct, especially that showing the fruit of his fern (fig. 2), from which really nothing can be learnt of the form and structure of the fructification. In his description he refers to the imperfect preservation of the fruit of his specimen, but among other remarks mentions that the fruit contains four or five sporangia (valves (Klappen) of an indusium according to Stur), which are directed downwards and only free at their upper part, that the upward directed portion of the fructification to which the supporting stalk is attached is convex, and that the fruit is 2-3 millim. long and 1·2-1·4 millim. broad. Notwithstanding the somewhat imperfect condition in which the fruit is said to be, a very distinct woodcut of the same is

[1] Carbon-Flora, i., p. 265, pl. xxxviii., figs. 1, 2 (1885).

given on p. 238, fig. 40. Accepting, then, this figure and description as correct, *Crossotheca fimbriata* is essentially distinct from *Calymmatotheca schatzlarensis*, Stur. In *Crossotheca fimbriata* the *synangia* are broader than long, having a breadth of from 3-4 millim. and a length of about 2 millim. in the compressed condition. Again, in *Crossotheca fimbriata* the sporangia are numerous, narrow, oblong, or linear, and are united to each other throughout almost the whole of their length. The fructification of the two species is therefore altogether dissimilar. It is possible that the specimens examined by Dr Stur were not so fully developed as those figured by me, for on some of the small slabs from Yorkshire, on which the fruit appears to be younger and scarcely so well preserved as in the specimens I have figured, the entire synangium is oval and but little broader than long, and in this condition it has a much closer approach in general appearance to fig. 40 given by Stur on p. 238 of his "Carbon-Flora" than to those given on my plate.

The affinities of *Crossotheca fimbriata* are clearly *Marattiaceous*. In the union of the sporangia to each other, their attachment to an oval (or circular) disk, and in their forming a cup-like synangium, they have a considerable similarity to the synangia of *Kaulfussia*, Blume; but in *Kaulfussia* the synangia are scattered on the back of the frond, not on por-

In *Renaultia*, to which *Cyclotheca* has also some affinity in the structure of the sporangia, the sporangia are situated at the extremities of the veins either singly or in groups of from two to five. *Cyclotheca* differs from both these genera in the sporangia, being circular and arranged in two parallel rows—probably one row was situated on each side of the midrib of the fruiting pinnule.

Cyclotheca belongs to the Marattiaceæ, and is more closely related by the structure of its sporangia to *Angiopteris* than to any other recent genus.

Cyclotheca biseriata, Kidston, n. s.
(Pl. XXI., figs. 10-12.)

Description.—Characters of genus. The sporangia measure ·50 millim. in diameter, and their walls are composed of small cells not elongated more in one direction than the other.

Remarks.—This species is founded on a single specimen which was collected by Mr P. Jack near Baillieston. Fig. 10 shows the fossil, natural size. It consists of several pinnæ lying on each side of the rachis, of which a small fragment is shown towards the centre of the figure. With the exception of this fragment of rachis there is nothing preserved in the fossil but the parallel rows of sporangia. These are well preserved and shown at fig. 11, magnified six and a half times. At fig. 12 are given four sporangia, magnified twenty times. Although no trace of a midrib is shown, one probably lay between the parallel rows of sporangia.

The small specimens originally figured by Lesquereux as *Staphylopteris asteroides*[1] probably belong to the genus *Cyclotheca*.

It is impossible to say to which fern the Baillieston fructification belongs. As the fruiting portion of ferns often assumes an outline so entirely different from that of the barren condition, I refrain from any suggestion upon this point.

Locality.—Ellismuir, Baillieston, Lanarkshire.

Horizon.—Lower Coal-measures: shales above the "Killongue" Coal.

[1] Rep. Geol. Survey of Illin., vol. iv., pl. xiv., figs. 8-10.

Note.—Since this paper was put into type I have been favoured by my friend, M. Crépin, Director of the State Botanical Gardens, Brussels, with two fruiting specimens of *Calymmatotheca schatzlarensis*, Stur, from one of the original localities — Charbonnage de l'Agrappe, Framerier (Fosse Grand Trait), Belgium. With these I have compared the Yorkshire examples, and find that the plant I had named *Crossotheca fimbriata* is the *Calymmatotheca schatzlarensis*, Stur. The woodcut given by Stur of the fruit of his fern (*l. c.*, p. 238, fig. 40) is therefore quite misleading, and does not at all represent the fruit of the plant from the same locality which has been forwarded to me by Mons. Crépin under Stur's name. In fact the description Stur gives of his admittedly badly preserved fruit leads one to inquire whence the evidence has come for the creation of his fig. 40.

The fossil remains, however, in the genus *Crossotheca*, but under the name of *Crossotheca schatzlarensis*, Stur, sp.

Explanation of Plate.

Crossotheca fimbriata, Kidston.

Figs. 1-3. Fruiting pinnæ.

Figs. 4 and 5. Synangia, enlarged 6½ times.

Fig. 6. Portion of a Synangium, enlarged 18 times.

Figs. 7 and 8. Fragments of barren pinnæ.

a few other localities, this fern is one of the most characteristic fossils.

In 1858[1] Mr W. H. Baily, in describing the fructification of *Archæopteris hibernica*, Forbes, sp., said that "one of the fertile pinnules of a specimen showed the spores were aggregated into clusters of sori, and that the indusium or protecting cover had been but little broken up. A fertile pinnule from another specimen, however, appeared to be in a more advanced stage, losing in a great measure the aggregated character of the sori, and showing the protecting cases (which were granulated) to be much disturbed.

"Other specimens in the collection were alluded to, one of which, with a length of 16 inches, had 12 pinnules on each side of the rachis in full fructification without any appearance of leaflets, the spore-cases being scattered in all directions; another of the same length had about twenty pinnules on each side, the lower ones being in full fructification, which decreased gradually towards the upper portion of the frond, the leaflets taking its place."

At the same time Mr Baily exhibited a diagram illustrating "what was considered to be the base of the stem or rhizoma, having a rounded expansion, apparently separating into scales which continued upwards, fragments of leaflets being attached to the stem at different intervals."

Schimper, in 1869,[2] figured and described *Cyclopteris hibernica*, Forbes, under the name of *Palæopteris hibernica*. In describing the fruiting pinnules he says: "These have undergone a complete metamorphosis, and are transformed into groups in which all foliar expansion has entirely disappeared, and which show a principal rachis not at all represented in the sterile pinnules which are destitute of a medial nerve." He also describes the sporangia as clavate costate ("soris (sporangiis ?) costulatis"). He gives an enlarged drawing of the sporangia at pl. xxxvi., fig. 4.

More recently Mr Carruthers redescribed the fruit of this fern.[3] Among other things he says:—"In some specimens

[1] Brit. Assoc. Report, 1858, p. 75.

[2] Traité d. paléont. végét., vol. i., p. 475, pl. xxxvi.

[3] Geol. Mag., vol. ix., No. 2, Feb. 1872.

in the British Museum all the lower pinnæ are entirely fertile. I am satisfied that the ovate-oblong sori are generally single, and not clustered, and are two-lipped, the slit passing one-third of the way down the sorus. The vein is continued as a free receptacle in the centre of the cup or cyst, as in existing *Hymenophylleæ*, in which it is included, not reaching beyond the entire portion. In some specimens the receptacle is broad or thick, indicating the presence of something besides itself in the cup, and giving the appearance that would be produced if it were covered with sporangia; I cannot, however, detect any indication on the outer surface which might have been expected from the individual sporangia. The compression of the specimens in the rock, which has made the free receptacle appear like a vein on the wall of the cup, together with the highly altered condition of the rock in which the fossils are contained, account for the imperfect preservation of the minute structures.

"The interpretation which I have here given of the fructification of this interesting fossil exhibits so close a resemblance to what we find in the living genus *Hymenophyllum* that, were it not for the vegetative portions, I would without hesitation place it in that genus."

Crépin,[1] in 1874, figured and described some specimens of *Archæopteris* (*Palæopteris*) *hibernica*, var. *minor*, from Évieux,

Cyclopteris hibernica and its generic associates, as *Palæopteris*, Schimper, is inadmissible, the name having been previously used by Geinitz for a different group of plants.

Among the Canadian species described by Dawson the point of chief interest to us is the figure and description of the fruit of *Archæopteris gaspiensis*, a very closely allied species, if really distinct from *Archæopteris hibernica*, Forbes, sp. His description of the fruit is as follows:—"Fertile pinnæ with about twelve pinnules, each having a long midrib with about seven pairs of crowded oblong spore-cases about 3 millim. in length, pointed or somewhat obtuse at top, straight at the sides, and apparently dehiscent at the apex. The midrib projects some distance beyond the spore-cases." It is further mentioned that *Archæopteris gaspiensis* "differs from *A. hibernica* in the arrangement and form of the spore-cases and in its shorter pinnæ, with fewer and less obtuse pinnules."[1]

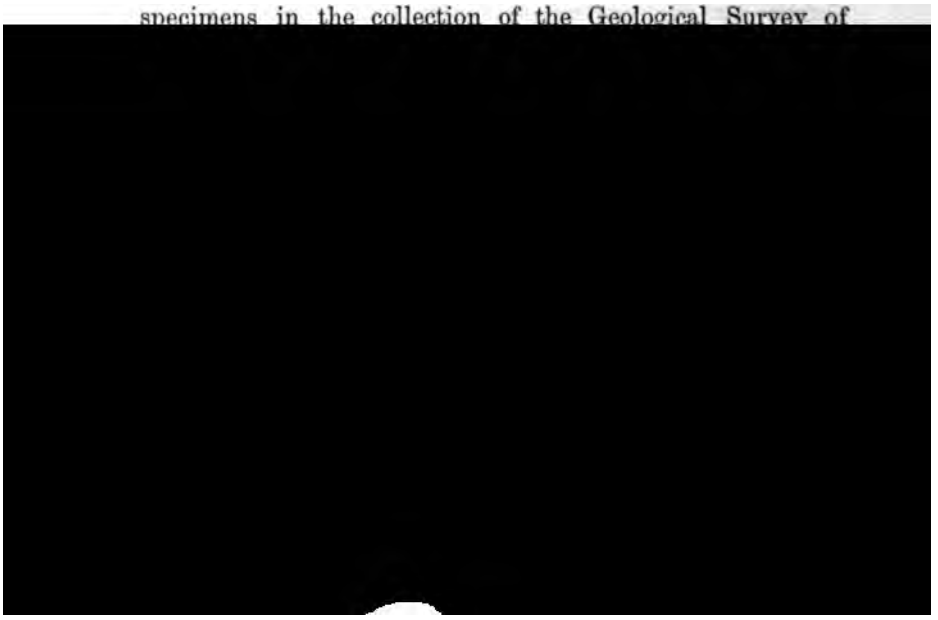
Since examining the specimens of *Archæopteris hibernica* in the British Museum, I have doubted the accuracy of the description of the fruit of this fern as given by Schimper and Carruthers, but refrained from expressing any opinion till I had an opportunity of examining the specimens of this plant in the collections of the Science and Art Museum, Dublin, and of the Geological Survey of Ireland. I have now examined these specimens, and feel convinced that the description of the fruit as given by Schimper and Carruthers is inaccurate. I have entirely failed to observe the presence of a keel on the sporangia, as figured by Schimper, or the occurrence of a "slit passing one-third of the way down the sorus," or any of the other Hymenophyllaceous characters mentioned by Mr Carruthers. The sporangia (so far as my observations have gone, and I have examined minutely the specimens in the British Museum, as well as those in the two collections in Dublin, the finest of which are in the collection of the Geological Survey of Ireland,) are narrow-oval, sessile, or very shortly stalked, as a rule pointed at both extremities, though occasionally blunt; they are usually developed singly, though occasionally in pairs, and are

[1] Dawson, *l. c.*, p. 99.

apparently produced on the upperside of the rachis-like vein of the very much metamorphosed pinnules, which in this case almost assume the structure of pinnæ, though their being only modified pinnules is proved by their position and by the occasional occurrence of a few sporangia on the margin of some of the foliage-pinnules, which, in the few such cases observed, had undergone but little reduction in the limb of the pinnule. A similar production of sporangia on the incompletely modified foliage-pinnules is not uncommon in *Osmunda regalis*. The fruiting-pinnules end in several simple or divided thread-like filaments. The fruit appears to consist of *exannulate Marattiaceous sporangia*.

Another interesting point was observed on some of the specimens in the collection of the Geological Survey of Ireland. This had evidently been noticed by Mr Baily, though its importance was not fully appreciated, and is referred to by him as a rounded expansion of the base of the stem, which apparently separated into scales. Mr Carruthers, evidently referring to the same structure, says, "The stipes were thick, of considerable length, and clothed with large scales, which formed a dense covering at the enlarged base." [1]

The structures here alluded to are two large *stipules*, one on each side of the base of the rachis, and on some of the specimens in the collection of the Geological Survey of



remain the slightest doubt in my mind that the true position of *Archæopteris hibernica* is in the Marattiaceæ.

In conclusion, I have to express my thanks to Dr A. Geikie and Prof. Ball for all the facilities they kindly gave me for examining the specimens in the respective collections of the Geological Survey of Ireland and in the Science and Art Museum, Dublin.

XLII. *Notes on the Equipment of the Research Laboratory of the Royal College of Physicians, Edinburgh.* By G. Sims Woodhead, Esq., M.D., F.R.C.P.Ed., F.R.S.E.

(Read 21st March 1888.)

The question of equipping a Research Laboratory has, for the past three years, occupied a very prominent position in the discussions of the Royal College of Physicians, Edinburgh, but it was only last year that the Committee appointed by the College was able to throw the plans into a shape feasible, and at the same time thoroughly acceptable.

When the matter had been taken in hand, the Committee, with Dr J. Batty Tuke as Convener, entered into the scheme with great energy and thoroughness, and within a very short time suitable premises were acquired, the necessary structural alterations were commenced at once, a Superintendent was appointed, apparatus was ordered, and fittings were put in hand to be ready for use as soon as the building should be prepared for their reception.

The premises are well adapted to the purpose for which they were acquired. They consist of a three-storied house, No. 7 Lauriston Lane, near the Royal Infirmary, to which had been added a large detached room. There are also commodious outhouses, and a plot of ground of considerable size at the rear of the building.

Commencing on the ground floor we first come to the room in a back court, set apart for experimental Physiology, 32 feet in length, 18 feet in breadth, and 14 feet high. It is well lighted by 7 windows, three of which,

facing to the west, are fitted with tables for microscopic work; between each of these tables is a cupboard and

Fig. 1.

a range of shelves for the reception of material. On the south wall is fixed the Cambridge Scientific Instrument Company's respiration apparatus, driven by water-power. On the east side at the south corner are drainer and wash basin. Near to this is a small Thirlmere water

Fig. 2.

motor used for driving light (1 in.) spindle shafting, which is fixed to the wall by six brackets placed above the windows and doorway. From this, recording apparatus may

be driven at any part of the room at 360 different speeds. The northern end of the room is occupied by a large cabinet, in which are stored the various pieces of apparatus.

Near the south end is a stone pillar bedded in the ground, so arranged as not to be affected by movements in the room. There being no thoroughfare in the lane, no disturbance can arise from wheel traffic. Around the pillar is fixed a table to which the galvanometer wires are attached. The galvanometer is placed on the stone pillar in a glass case with a hinged door, and is always kept ready for use, short wires being carried from the table to the instrument. A

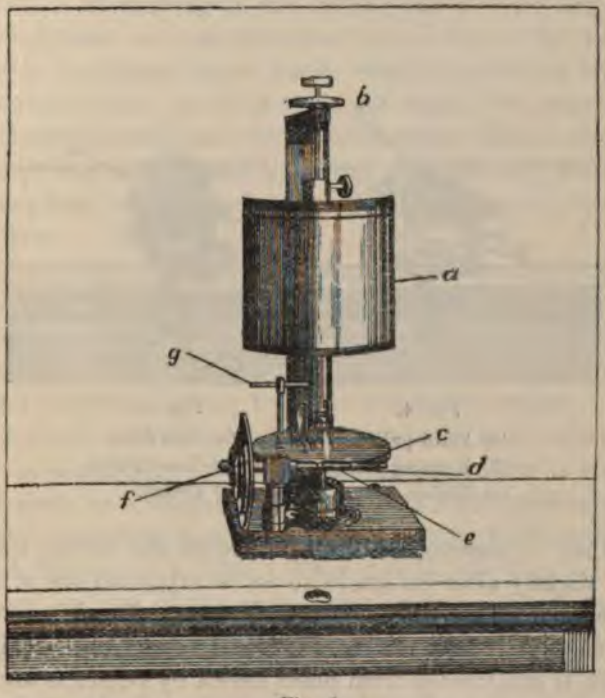


Fig. 3.

(*a*) Drum; (*b*) screw bearing-point; (*c*) toothed wheel; (*d*) coarse worm; (*e*) finer worm; (*f*) driving pulley.

hinged lamp table, and brass rods over which curtains are hung, complete the galvanometer fittings. Work tables occupy the remainder of the centre of the room.

The recording drum (Fig. 3) designed by Dr Milne Murray,

and made by Hume, Edinburgh, is a modification of the worm screw form. On the spindle driven by the pulleys (*f*) are two worm threads, a coarse one (*d*) and a finer one (*e*). On the drum spindle are two wheels (*c*), one with large, the other with smaller cogs, corresponding in size with the worms on the different sections of the spindle. The upper wheel with the fine teeth is driven by the fine worm which is placed nearer the driving pulley; the lower wheel, smaller in diameter, is driven by the coarse worm, placed at the end of the screw. In order to obtain the different rates of speed from these,

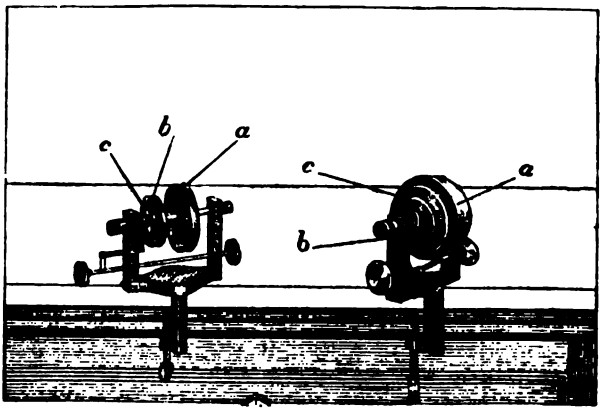


Fig. 4. Fig. 5.

which a cone covered with leather is attached to the loose wheel; the fixed wheel is bored and lined with leather to receive this cone.

Another form of clutch designed for me by Mr James Ritchie, Jun., of Edinburgh, is one in which there is a fast drum (*a*) grooved to carry the cord running from the shaft (Fig. 5). Running on the spindle to which this drum is fixed, is a loose three-speed cone pulley (*b*) with a groove and clutch (*c*). Between the loose pulley and the fixed drum is a friction clutch consisting of three straight pieces of metal, which when out of gear are so arranged as to form a small arc of a circle. By pushing in the middle one of these the arc is straightened out, and the outer extremities of the two end pieces are pressed into a groove running round the inside of the fixed drum. In order to fix the clutch, the centre piece is simply made to pass the perpendicular; there is no spring except that in the metal of the rim of the drum. The clutch never fails, works noiselessly and without the slightest loss of time.

Electrical, time-marking, and other apparatus, tuning-forks, perfusion apparatus, shunts, compensators, etc., constitute the greater part of the instruments in this room. Marriott's arrangement for obtaining regular pressure for injecting and other purposes, is hung from the roof at two points.

At each window table on the west side is a bell jar, used for protecting the microscope from dust. This is counter-balanced by a weight which runs on a brass guiding-rod, so that there is no danger of breakage to the window through swinging of the weight. When not in use the bell jar is drawn up out of the way towards the ceiling. Such an arrangement economises room and prevents breakages.

On each microscope table, which is painted black and hard varnished, a white band about four inches broad is painted, four inches from the edge of the table. Some of the tables instead of being varnished are covered with plate glass, painted as above on the under surface, and embedded in felt. On these glass-covered tables the microscope stands on a felt circle, to diminish the risk of breakage when the bell jar is lowered over the microscope.

The sink and draining apparatus in this room may be taken as a type of those throughout the whole building. It consists of a large earthenware sink, on one side of which is a grooved draining board covered with lead, the grooves all leading to the sink. A swan-neck tap supplies the water. To this tap are two nozzles, to one of which is wired a piece of india-rubber tubing, used to connect the Geissler exhaust pump, etc.; the other nozzle gives a steady unbroken jet of water $\frac{3}{8}$ in. in diameter.

The wall behind the sink is leaded for about three feet up; against this are fixed a couple of shelves, the upper one perforated for draining flasks and bottles, the lower one grooved and with a gentle slope to carry all droppings to the sink. Below these shelves are a couple of rows of wooden pegs, fixed into the wall at an angle of 45°. These are very useful for draining all kinds of glass apparatus.

In the main building in the lower flat is a large entrance lobby (Fig. 6), to the left of which is a part of the Laboratory

plate, so that after a few sections have been made, the plate with the piece of tissue may be removed and put aside until again required. There has also been added a tin box about four inches deep, with a bottom an inch from the lower margin of the sides; this box fits over the second plate. It is provided with a lid, has the bottom sloping to one end, and has an outlet pipe, to which a piece of india-rubber tubing may be attached. It is filled with ice and salt freezing mixture, and its use greatly hastens the freezing of the mass of tissue to be cut.

On the second flat, three of the five rooms are occupied by the Laboratory Assistant. Of the others, a large room is set apart for Committee Meetings, and is used as a Library and Museum. It is also fitted with an Oertling's short

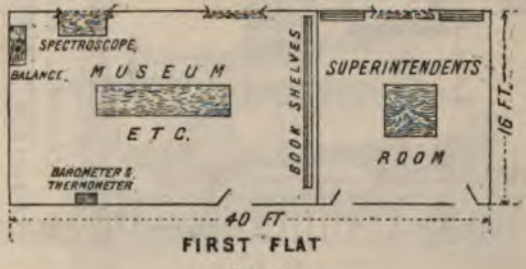


Fig. 7.

beam balance, supported on a solid iron bracket let into the wall.

A certificated barometer graduated in inches and millimetres, and a thermometer with Centigrade and Fahrenheit scales, are placed here for temperature and pressure corrections.

There is also a large spectroscope made by the Cambridge Scientific Instrument Company, with Steinheil's prisms. It is protected when not in use by a glass case, counterbalanced in the same way as are the bell jars at the microscope windows.

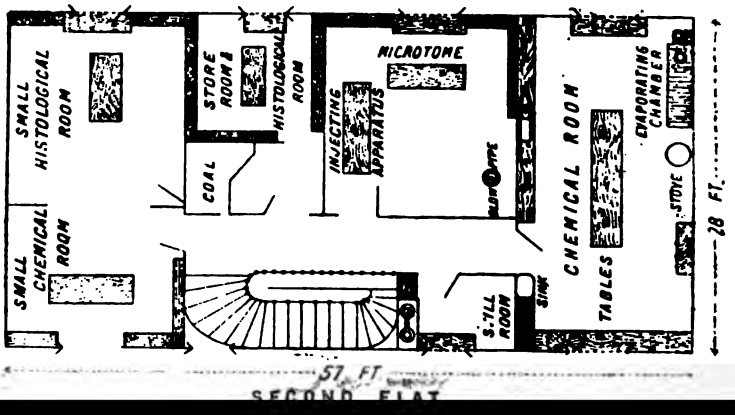
A museum case, book shelves, and writing tables complete the fittings in this room.

The fifth room on this flat is the Superintendent's private

room, where the administrative work of the Laboratory is carried on.

On the next landing are six rooms; the first of these, a small one, is used as a still room; the still is connected with the water pipe and is self-feeding, so that to obtain a supply of distilled water all that is necessary is to turn on the tap and light the bunsen burner.

A second room—the chemical room—is fitted with a good supply of water and gas. There are eight water taps in the room, seven of which are swan-necked with the double nozzle already described. Two ends of the room and the evapor-



one end and opening into the chamber, resting on the stone slab continued outside the chamber, is one of Fletcher's Sand-baths. This room is stocked with most of the apparatus necessary for carrying on physiological chemical work, the analysis of air, water, food, and the rest.

The next room is set apart for blow-pipe work, metal injections (Cathcart's method), embedding in paraffin and celloidin, and section cutting. It is also used as a store room for some of the glass apparatus, and the window is fitted with a table for histological work.

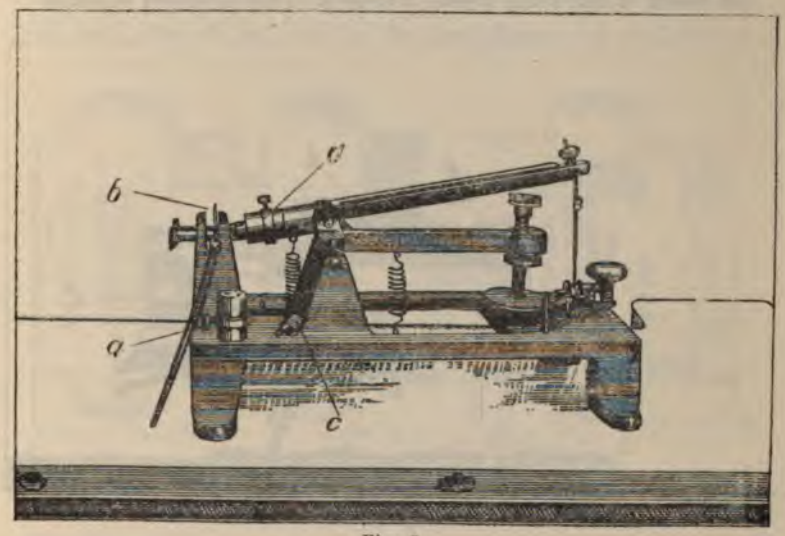


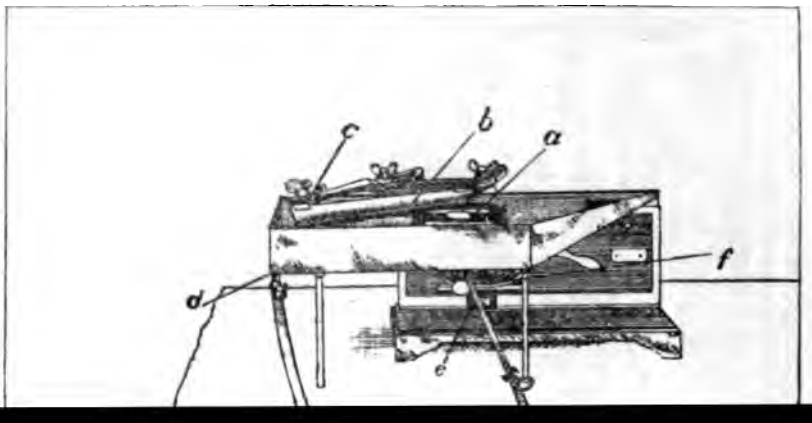
Fig. 9.

(*a*) Binding screw and tube; (*b*) razor in position; (*c*) die with block attached; (*d*) die, etc., in position.

Several modifications have been made in the microtomes used in this room. To the Cambridge rocking microtome Mr Fraser added for me a fixing screw (*a*) to steady the tube in any position on the iron lever, and at Mr G. Brook's suggestion I also added a solid end to the brass tube, into which "dies" (*c*) of various sizes with roughened surfaces can be screwed. This does away with all the inconvenience of having to "melt in" the embedded tissue into the tube. A dozen of the dies may be used, and to each of these a

piece of tissue may be fused, and kept ready for cutting at any time. Then, too, the die with its piece of tissue may be unscrewed, after a few sections have been cut, and another substituted; the fixing screw enables one to adjust the holder and tissue as required.

To a large Schanze microtome, which is used principally for cutting tissues embedded in celloidin, an arrangement has been fitted (Fig. 10) to allow of sections being cut under spirit. To the knife block that runs in the groove I have affixed a second bevelled plate, so adjusted that it throws down the point of the knife about 2 inches. This bevelled block is



filled in by means of an india-rubber bag (Nachet's plan), fixed by wire to a flange around the opening and by a nut with a washer around the clamp rod. The tray is filled with spirit which cannot escape except by special taps, but the specimen can be raised by means of the screw, the india-rubber bag allowing considerable movement but preventing the escape of the spirit. At one corner of the tray is a grating with a tap beneath (*d*), by which the spirit may be drawn off, whilst in the india-rubber bag there is also a tube (*e*) with a Mohr's clip through which the remainder of the spirit may be removed. At each end of the body of the microtome is a ring with a

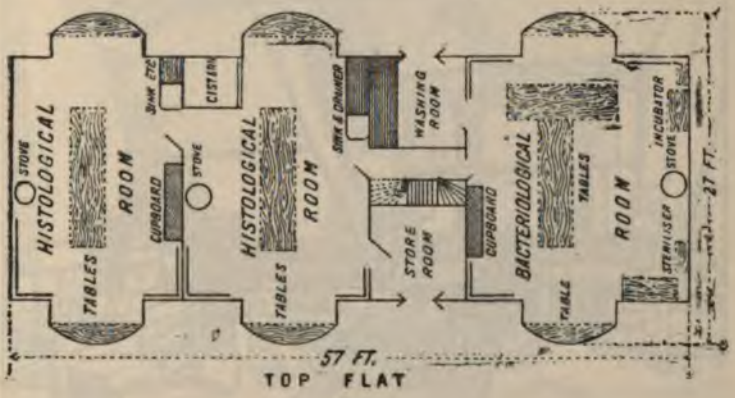


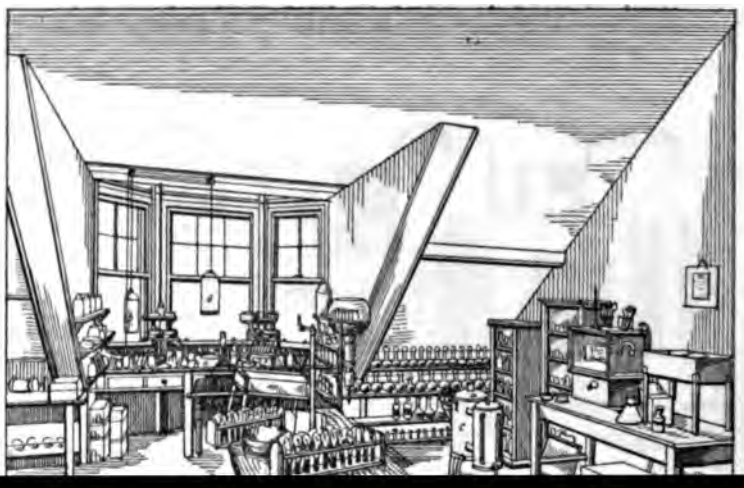
Fig. 11.

binding screw in which a rod may be fixed to prevent the knife point or heel coming in contact with the ends of the tray. We have found this a most convenient arrangement, especially for large sections 3 or 4 inches square. Mr Hume gave me very great assistance in working out the details of the above piece of apparatus, the workmanship of which does him great credit.

Next door on this same flat is a small room used as a store for reagents and other chemicals; the window is fitted with a table for microscopic work. Then comes another small histological room, and lastly a room set apart for the estimation of urea, albumen, and sugar in urines, in

connection with clinical work undertaken by the Fellows of the College.

On the top story are three splendidly-lighted rooms (Fig. 11), all of which are devoted to microscopic work. In the south room the apparatus necessary for Bacteriological research is collected. Two large projecting roof or dormer windows (Fig. 12) face east and west respectively. Each is fitted with a table covered with a sheet of plate glass, on the under surface of which are painted three strips, the first 4 inches broad, black,



Above the level of the table, in front, are four small shelves, on which are placed covered vessels for clean and dirty slides and cover glasses. A syphon arrangement for distilled water and corrosive sublimate solution, a bell jar with counter poise running on a brass rod, a bunsen burner, and a lamp, complete the fittings at this table. This lamp (Fig. 13) is

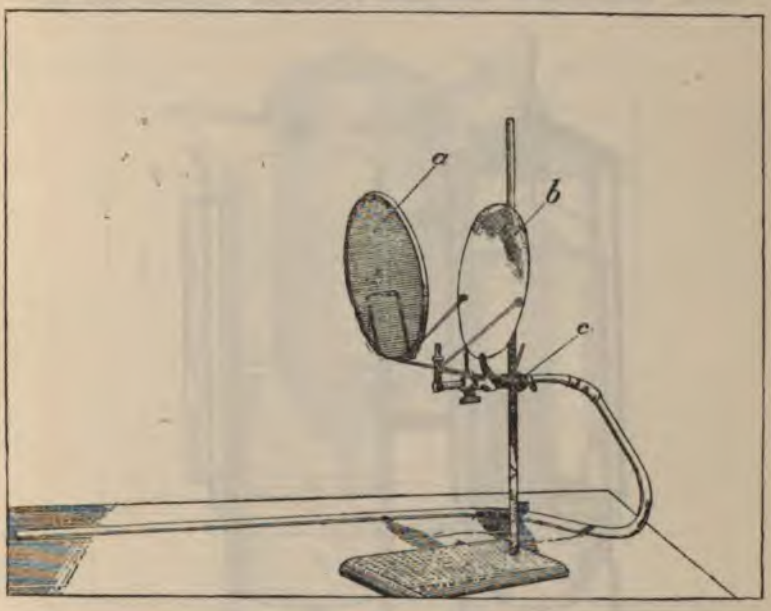


Fig. 13.

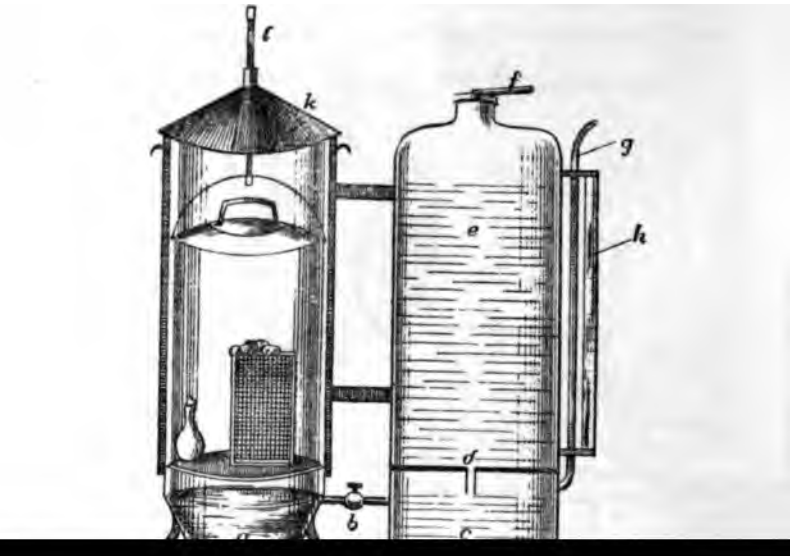
(*a*) Blue glass ; (*b*) opal reflector ; (*c*) retort stand.

at once cheap and very effective. It consists of a wire frame soldered to a piece of brass piping into which is fixed an ordinary gas burner. Behind the burner on the wire supports is fixed a concave reflector (*b*) made of opal glass (sold for the top of ordinary gas globes), and in front is a piece of blue glass (*a*), which protects the eyes of the worker from the strong glare, whilst it allows of all the table being thoroughly and brilliantly lighted. The lamp is supported on an ordinary retort stand (*c*).

The bunsen burner found best adapted for our work is that made by Messrs Fletcher, with wire gauze both above and below.

A very small flame may be obtained, and there is little or no risk of the flame running down the tube to the lower orifice.

Each microscope table has similar fittings. The pieces of new apparatus in this room are, first, a steam steriliser (Fig. 14), modified from one suggested by Dr Aitken on the principle of Bunsen's continuous supply for the hot water evaporating bath. It consists of two parts, the steam chamber and the



about half an inch in length. This is the only means of communication between the two reservoir chambers. Between the lower chamber and the lower part of the steam chamber runs a piece of half-inch tubing (*b*) on which is a stopcock. From

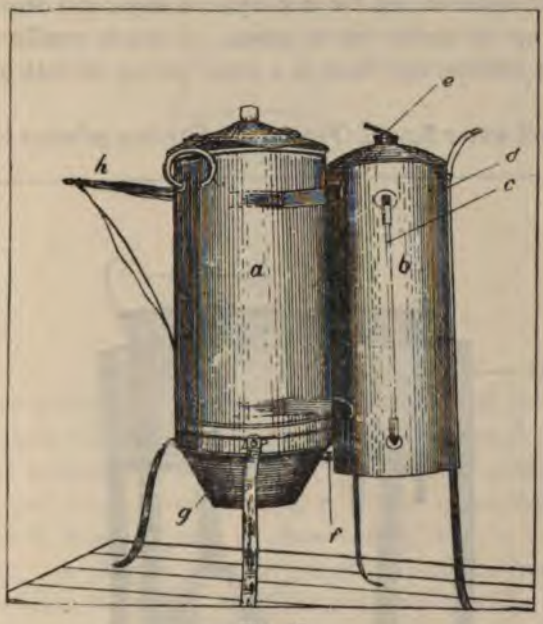


Fig. 15.

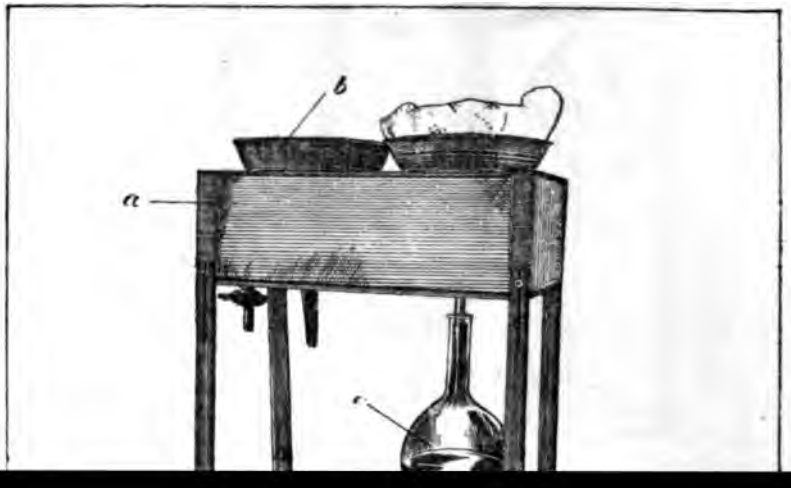
(*a*) Steam chamber; (*b*) reservoir; (*c*) water gauge; (*d*) air pipe; (*e*) orifice for filling reservoir; (*f*) communicating tube between two chambers; (*g*) copper bottom; (*h*) rest for can.

the lower chamber there is also a tube (*g*) running up the outside of the cylinder through which air can gain access. Attached to the upper chamber is a glass water gauge (*h*), and at the top in the middle is a supply opening. This is closed by a levered screw cap (*f*), lined with india-rubber, in order that the joint may be perfectly air-tight.

To set this to work, close the tap, cutting off communication with the steam chamber; screw off the cap and fill up the reservoir with water; screw on the cap firmly, then open the tap between the two chambers; water immediately escapes from the one into the other until it rises to the level of the lower end of the pipe in the false bottom (Fig. 15); as soon as it

gets to this level no water can escape, as the upper chamber is now air-tight. Only a small quantity escapes at a time, and this is very rapidly boiled; as it evaporates a small quantity escapes to take its place, and so on. The reservoir holds sufficient water to last for a couple of days, and steam can be got up in under ten minutes. A much smaller steam chamber suffices, and there is a great saving of both gas and time.

The hot water funnel (Fig. 16) for filtering gelatine is made



test tubes with a pipette, the following method (Fig. 17) has been devised,—into each of the large stock flasks, in which the peptonised gelatine is sterilised and stored, is fitted an india-rubber bung with two openings. Through these pass two tubes, one with a thistle head tube running to near the

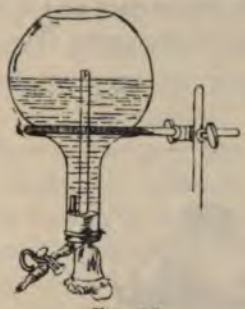


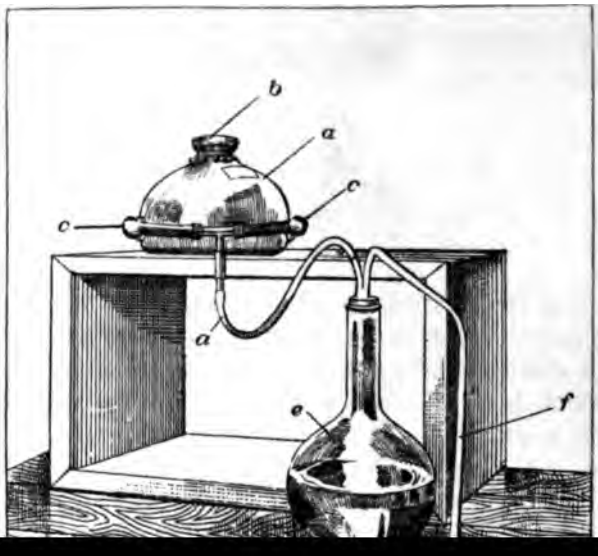
Fig. 17.

surface of the gelatine, *i.e.* about two-thirds of the distance down into the flask, the other passing just through the cork. To the shorter tube is fitted a piece of india-rubber tubing on which is a Mohr's clip, and to the other end of this tubing is fitted a piece of glass tubing with a constricted orifice. A plug of carefully sterilised cotton wadding is pushed into the thistle head, the india-rubber bung is pushed into the neck of the flask, and then a sheet of cotton wadding is placed over the whole of the tubes and the mouth of the flask, and is held in position by an india-rubber band. The flask is placed in the steam steriliser, where it may be left for a sufficient length of time to allow of it becoming perfectly sterilised. It is filled nearly a third full with gelatine, after carefully removing the sheet of wadding and the bung; these are then replaced, and the whole is again sterilised as usual.

When the gelatine is to be drawn off into test tubes, the flask is inverted and held in a retort stand, the sheet of wadding is carefully removed and folded, the glass nozzle is inserted into the mouth of the test tube, the clip is opened and gelatine escapes; all the air passing into the flask, being filtered through the wadding in the thistle head funnel, is thoroughly sterilised. If the whole of the gelatine is not withdrawn, all that is necessary is to replace the sheet of

wadding (care having been taken to preserve the inner surface, by folding it inwards). There is no necessity to sterilise after this has been once done, all that is necessary subsequently is to heat sufficiently to render the gelatine fluid. This apparatus is specially useful for milk, as the cream always rises to the surface and is so left to the last.

Another new piece of apparatus (Fig. 18) is one which I



one is enabled to get a large surface of gelatine, and a more perfect diffusion of the organisms on the surface.

The points of growth are easily counted through the flat glass bottom and transparent layer of gelatine. Another great advantage is that if the orifice at the top be made large enough ($1\frac{1}{4}$ inches in diameter) the points of growth may be as readily removed, as from a plate cultivation, the manipulator being able to reach any point of the surface of the gelatine with his platinum needle.

One of Browning's microspectroscopes has also been fitted up in this room. Racks, for series of Hesse's tubes, and shelving complete the fittings. Opening out from the bacteriological room is a small room with a sink and large sloping drainer, at which most of the glass apparatus is washed.

The other two rooms on this flat are fitted up for histological work with window tables, sinks, cupboards, spirit vessels, and shelving, each for two workers.

In connection with the histological department, apparatus for microphotography has been fitted up by Mr Forgan.

A smaller form (Fig. 19) consists of a base board on which the microscope (*b*) (with the eyepiece in) is fixed with a lamp (*a*) in front. The microscope stands between two firm uprights 26 inches high, at the top of, and between which, is a cross bar holding a frame for focussing glass and dark slide. The space between the dark slide and the microscope tube is filled in with a black velvet funnel-shaped tube (*c*), which is easily fixed around, or removed from, the tube. In using this apparatus the specimen to be photographed is first fixed and focussed on the microscope ordinarily used, which is then placed on the base board and carefully lighted from the lamp in front. The velvet funnel is drawn over the eyepiece and tube, the image is focussed on clear waxed glass (*d*), after which the dark slide is introduced. Before drawing the shutter a piece of cardboard is placed between the mirror and the section. To expose, simply remove this cardboard for the necessary length of time. This apparatus can be used with advantage for low powers only. It may be used with daylight or with gaslight.

The larger form, for work with higher powers, is based on

the model of that used first in Germany. The special points to be noted in this are, (1.) the microscope (with

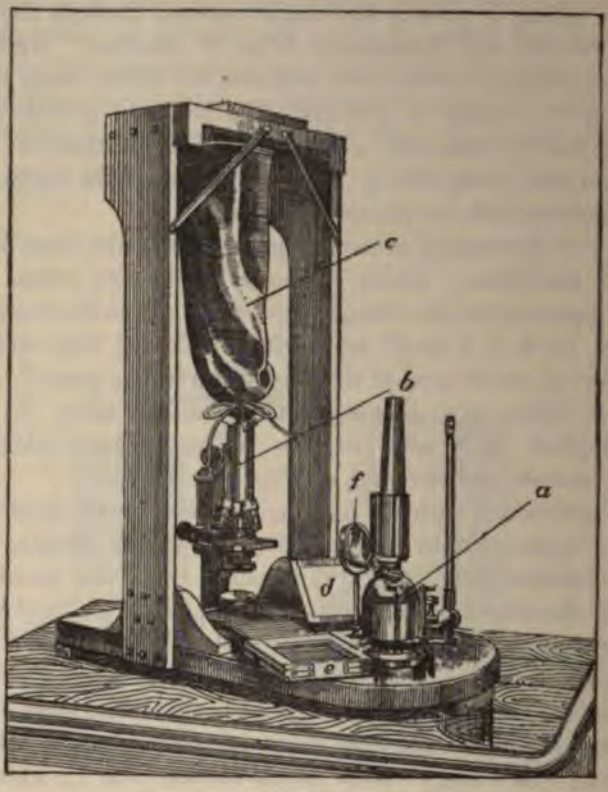


Fig. 19.

(*a*) Lamp; (*b*) microscope; (*c*) velvet tube; (*d*) focussing screen; (*e*) dark slide; (*f*) bull's eye condenser.

condenser attached) and lamp are placed on a board revolving on a pivot on the long base board, so that the object may be fixed and focussed before the microscope tube is inserted into the front of the camera. (2.) The focussing on the screen is rendered much easier by an arrangement suggested first by Mr G. Brook and then by Dr Edington, whereby the milled head of the fine adjustment screw is worked by means of a cord running from the end of the focussing rod over the groove of the milled head, sufficient friction being obtained by means of a plummet ball,

which should weigh, at most, a couple of ounces. In devising modifications of old apparatus and constructing new, I have been greatly aided by the mechanical ingenuity and skill of Mr Coghill, the Assistant in the Laboratory, to whom I now wish to express my great indebtedness.

The arrangements for conducting the work are somewhat as follows:—The College has established and will maintain the Laboratory for the prosecution of original research. To facilitate such work the Council of the College "appoint a scientific Superintendent, who must devote such portion of his time as may be determined by the Council to the work of the Laboratory; where, under the supervision of the Curator and Committee, he shall himself undertake the prosecution of original research, and be prepared to assist, if required to do so, in the work of other investigators. Under like supervision he shall also be prepared to furnish the Fellows of the College with reports upon such matters as the Histology of Morbid Specimens, and of the Chemical and Microscopic characters of Urines," in which work he is aided by the resident assistant.

The Laboratory is open without fee to Fellows and Members of the College, "to any Licentiate who shall obtain the sanction of the Curator and Committee to use the Laboratory for purposes of scientific research;" and "to any medical man or investigator, who shall obtain the sanction of the Council of the College, as well as of the Curator and Committee, to use the Laboratory for the purposes of scientific research."

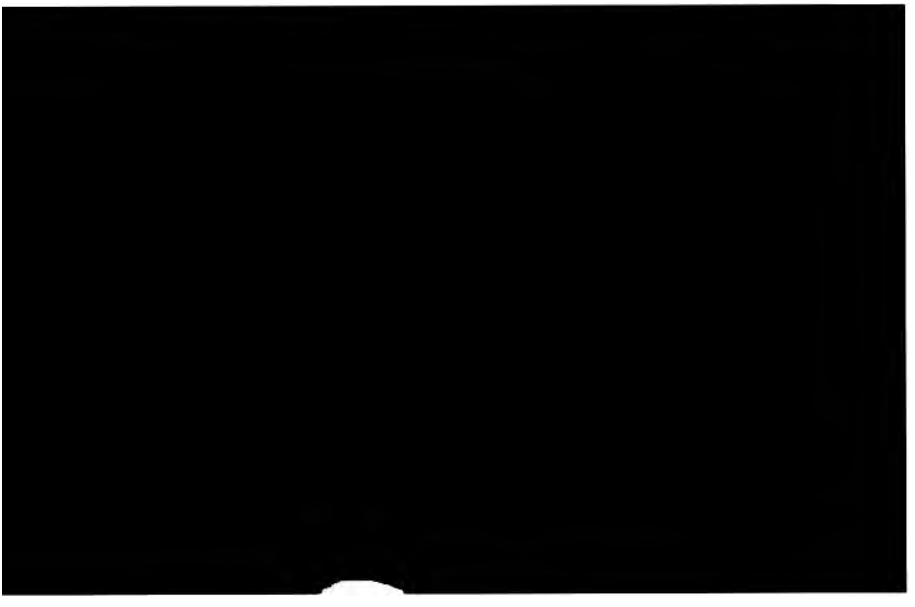
The Institution is open for research work daily, Sundays excepted, from 10 a.m. till 5 p.m., except on Saturdays, when it is closed at 1 p.m.

A special arrangement may be made by those desirous of working after the usual hours of closing, but for this the written permission of the Superintendent must be obtained.

Investigators are entitled to the assistance of the Laboratory officers or servants in the preparation of apparatus, but the actual work of carrying on experiments, cutting and mounting specimens, etc., must be done by the investigator himself.

The whole of the expense of establishment and maintenance has been and will be defrayed from funds placed at the disposal of the Committee by the Council of the College. Of this an initial grant of £1000 was made, with which to alter and furnish the house and buy apparatus, instruments, and chemicals. In addition to this an annual grant of £650 is made, from which all salaries, rents, and taxes are paid, and stock is kept up. Of these sums, only about £830 of the original £1000, and £600 of the annual grant, were spent during the first twelve months, so that the whole equipment and fittings of the Laboratory, together with the current expenses during the above period, cost only £1430. During the year there have been 22 medical men—9 Fellows, and 4 Members of the College and 9 other qualified medical men—engaged in pathological, physiological, chemical, or bacteriological investigations, some of which have been completed and will shortly be published. In addition, nearly one hundred tumours or other histological preparations have been examined, and numerous analyses have been made by or for the Fellows of the College and others.

The Laboratory has also been used for examination purposes in connection with the Diploma in Public Health granted by the College.



publication of Saxby's book in 1874. Saxby at that time remarked on the increasing numbers of various species of small birds that spent the summer in the islands, and confidently expected a still further increase every year. These expectations, however, have been in a great measure disappointed. Planting has very slightly increased, and if undertaken in the same manner as I observed at the Ness of Hillswick in 1887, must necessarily prove a failure. At that spot—an exposed position on the west coast—about a quarter of an acre had been planted with young fir-trees, all dead at the time of my visit; and to protect this young plantation from the fierce sea gales, there was erected round it a three-strand wire fence! In places inaccessible to sheep, such as islets in lochs and inland cliffs, a few dwarf natural trees may be found—all those I saw were ash, birch, and rowan, but in numbers too scanty to have any influence upon the fauna. Thus, owing to the absence of suitable shelter, the small birds we do find in Shetland are inhabitants of the hills, pastures, and rocks; and with the single exception of the hardy little wren, we see none of those sylvan species so common farther south.

Of the larger species of birds, such as the waders, and especially of the sea-fowl, Shetland possesses a long and important list of residents and summer migrants. Several species, rare or local in Britain, nest in the islands, such as the White-tailed Eagle (*Haliætos albicilla*), Redthroated Diver (*Colymbus septentronalis*), Rednecked Phalerope (*Phalaropus hyperboreus*), Arctic Skua (*Stercorarius crepidatus*), Whimbrel (*Numenius phæopus*), and one species found nowhere else in the British Islands, the Great Skua (*Stercorarius catarractes*). To these may be added a recent colonist, the Fulmar Petrel (*Procellaria glacialis*), which I believe has only one other breeding-station in the British seas.

In view of the interest attaching to local bird names, I give each bird's Shetlandic title immediately after its scientific one. Though perhaps not in harmony with the most recent theories of classification, I shall follow in this paper the order adopted in Saxby's "Birds of Shetland," and therefore will commence with

1. White-tailed Eagle (*Haliætos albicilla*), (Erne, Sea-Eagle). —This fine bird is not quite exterminated in Shetland, though it has, as elsewhere, become very scarce of late years. As far as I have been able to gather, there are still four or five occupied eyries. In the *Scotsman* for 6th August 1883, there appeared a long account of the capture of a pair of eaglets from a nest on the Bard of Bressay, in the previous June, by James Laurenson of Lerwick, which account, I am informed by the captor himself, is substantially correct. In June 1886 two Lerwick youths took a pair of eaglets from a nest close to this locality—on the Noup of Noss. Mr Howard Saunders, in a paper in the *Zoologist* for January 1880, throws doubt upon the eagles having built in this district in 1879, but I think it very probable they did so. There is another eyrie of the erne, which was tenanted in 1884, in the island of Fetlar, and another is situated in Yell. From this last a single young bird was taken in June of last year (1887). This bird is now in the possession of James Laurenson, and is "doing well." Besides these, I discovered another on the 3d of June 1887, on Mainland, and had the pleasure of seeing one of the old birds within a short distance. This eyrie is in an exceedingly difficult situation, protected from above and below by projecting points of rock. The old eagle, after sailing slowly past, mobbed all the while by the

with it on two occasions in 1887; one, a female, I put off her nest just under the "Horn of Papa," on the island of Papa-Stour, and another on Roeness Hill. The first-mentioned bird was very bold, and kept flying backwards and forwards, screaming loudly. Probably her young were newly hatched. The puffin forms a very favourite prey of these birds, and I met with large quantities of their remains near an eyrie in Unst.

3. Merlin (*Falco æsalon*), (Maalin, Sparrowhawk).—This beautiful little hawk is not at all frequent on the mainland, and I met with it only twice. One I saw chasing a raven on Roeness Hill; and a pair at the Bërgs of North Röe, the female of which I put off her nest, containing two eggs. The eggs were deposited in the old nest of a hooded crow (merely a slight hollow in the turf, surrounded by a rim of burnt heather stems), situated on the ledge of a low rock on a broken rocky slope.

4. Kestrel (*Falco tinnunculus*), (Maalin, Sparrowhawk).—The people as a rule do not distinguish between this bird and the last, and many of the eggs in the shops in Lerwick should more properly be assigned to the kestrel than to their nominal owner. The kestrel is, however, not abundant anywhere, and seems very local, and regular in its return to breeding haunts. Thus I found a nest with six young at a spot mentioned by Saxby as being frequented by them in 1869.

5. Hen Harrier (*Circus cyaneus*).—Said by Saxby in 1869 to be "rare even as a visitor." I did not meet with it, nor with any one who knew the bird.

6. Shorteared Owl (*Otus brachyotus*), (Catyogle) does not seem to be common. Mr Scott of Melby has heard them in the vicinity of Melby House. Saxby found a nest in heather between Bardister and Ollaberry, in Northmavine. I did not meet with it in any place.

7. Snowy Owl (*Surnia nyctea, Nyctea scandiaca*), (Catyogle).—There is little doubt that this owl used occasionally to breed in the island of Unst, though no instance has occurred in recent years. About 1822 Edmondston was informed of a nest with three young being found near Baltasound; and Saxby several times met with it in summer. In

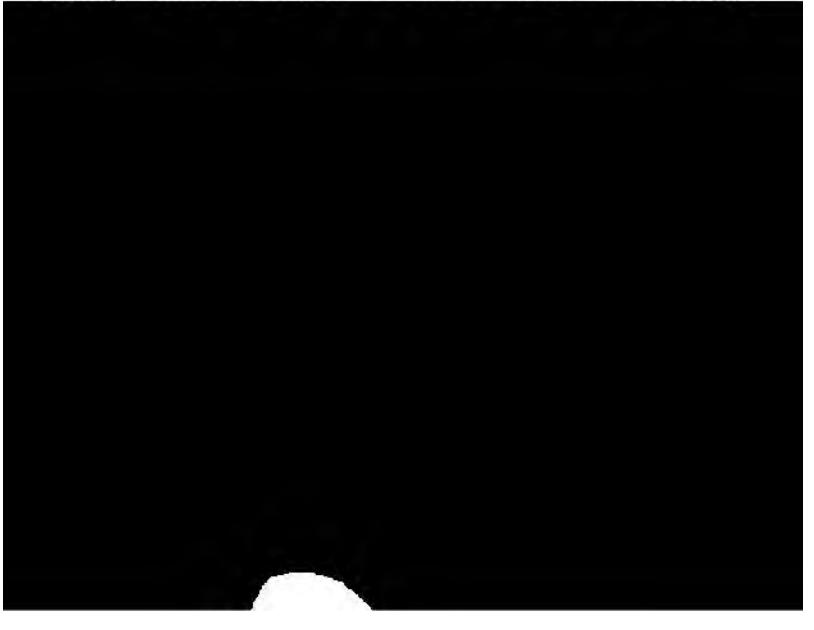
Wilson's "Voyage" also, mention is made of a snowy owl seen by one of his party on this same island in the month of August.

8. Redbacked Shrike (*Lanius collurio*).—One instance of this bird's nesting in Shetland is recorded: Saxby found a family of three young birds on 9th June 1870 at Burrafirth, in Unst.

9. Blackbird (*Turdus merula*) is reported to have bred in the vicinity of Lerwick, but there seems to be no authentic record of the fact.

10. Wheatear (*Saxicola œnanthe*). (Steinkle).—This is the most generally diffused of the land birds of Shetland. It is very common, and its sprightly notes may be heard during May and June all day long, and also throughout what would be night in more southern lands. The nest is placed in a hole in some peat bank, or in the interstices of the rocks, and is so cunningly concealed that it is rather difficult to find. The bird, too, seems to feel the turf shaking at a considerable distance off, and steals away from the nest before the intruder comes close upon it. All the nests I found were made of roots and grasses, and lined with a great mass of gulls' feathers.

11. Meadow pipit (*Anthus pratensis*), (Hill Sparrow, Titlark).—This is another of the commonest of Shetland



Now that this bird has been found breeding on the mainland of Scotland (Messrs Harvie-Brown and Buckley, "Fauna of Sutherland," pp. 138-142), we may expect to hear of its nesting elsewhere. During Saxby's stay in Shetland (he left in 1871) he procured no less than four nests, all from the same spot, the summit of Saxavord in Unst.

15. Common Bunting (*Emberiza miliaria*), (Cornbill, Bunton). — The bunting cannot be called common in any part of Shetland, though a pair or two may be seen in many places, usually perched on the telegraph wires, a habit which I have noticed they are very fond of in the vicinity of Edinburgh.

16. House Sparrow (*Passer domesticus*).—This truly parasitic bird is, as we might expect, as common in Shetland as elsewhere ; wherever there are a few houses the sparrow is sure to be seen, as impudent and familiar as farther south. It is particularly abundant in Lerwick, Scalloway, and Walls, and nests in the thatch of every hamlet.

17. Twite (*Linota flavirostris*), (Lintie).—The mountain linnet divides with the wheatear the distinction of being the most characteristic small bird of Shetland, and is generally distributed. The nests, like those of the wheatear, are rather difficult to find, being usually placed under a peatbank or in a tuft of heather. One, however, which I came upon while looking for gulls' eggs, was placed under a loose stone about 50 feet down a high and steep cliff. Another was placed in a turf wall.

18. Starling (*Sturnus vulgaris*), (Starn).—Is very abundant, breeding in large colonies in the cliffs, in houses, dry stone walls, and under the stones on the beaches of the island of Oxna — where Hewitson found the storm petrel nesting.

19. Raven (*Corvus corax*), (Corbie).—The raven may still be fairly termed common. In 1887 there were few days on which I did not see several of these birds. On the 27th May I put one off her nest at Burland, and on the 31st saw another nest-site, from which the young had not yet flown, at Feideland Point. In Walls, on the 10th June, I came upon a family party of two old and three young, the latter of which were barely

able to fly. The old birds were very bold, coming swooping round me croaking fiercely, probably seeing I carried no gun.

20. Hooded Crow (*Corvus cornix*), (Craa).—This destructive bird is very abundant in many districts, and nowhere more so than in the vicinity of Sandness in Walls, where it was to be seen in flocks of nine or ten feeding in the fields. All along the coast, and also inland wherever there were a few rocks, the old nests could be seen. Most of the young broods had flown at the date of my visit, but I found two nests with eggs on low inland rocks. One of these had been visited before, and the eggs partly blown and replaced. This I discovered had been done in the belief that the female would be induced to sit until she died. Of course she did nothing of the kind, and the eggs had been turned out of the nest, and were lying on the turf alongside. Two other nests with young, and many used nests which I came upon in inland situations, were all very easy of access, several indeed placed under stones on the open moor.

21. Wren (*Troglodytes vulgaris*), (Robin).—The reason why the wren should be called the robin in Shetland is not very apparent. The robin is an accidental visitor, while the wren is rather common, and may be found in all sorts of places —now singing sweetly from a stone half-way down a

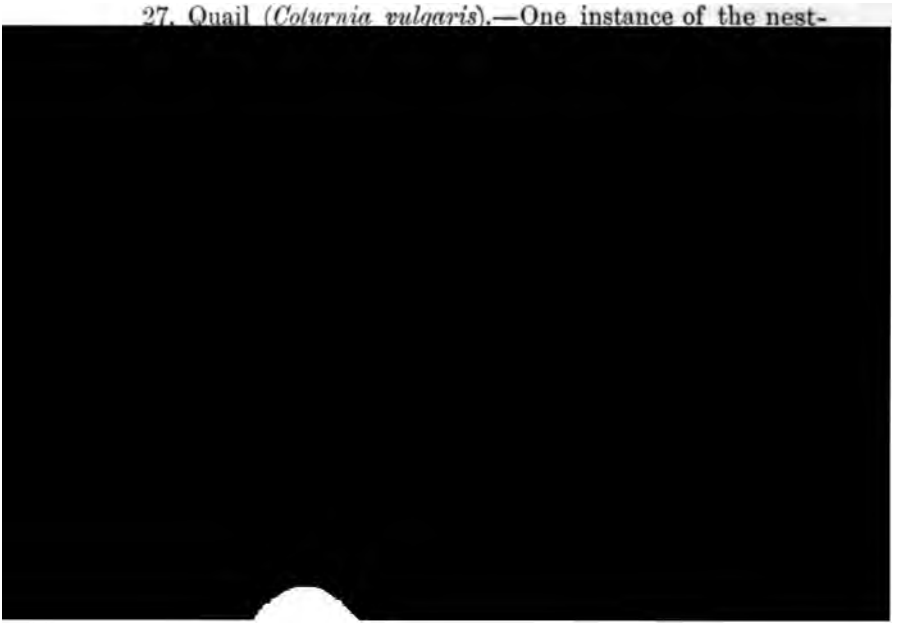
as rare as those of the swallow. It occasionally breeds, however.

25. Rockdove (*Columba livia*), (Doo). — Very numerous wherever there are suitable caves; all those I saw were pure bred birds, tame pigeons not being kept in large numbers in Shetland. The nests are invariably very difficult to reach—usually built in the roofs of sea-caves. One nest I got was placed in a rather curious position. While walking along the cliffs of Papa-Stour I saw a rockdove dart up apparently from the ground about 70 yards from the edge of the cliff. On going to the spot, however, I found she had come from a hole in the rock, at the bottom of which, about 150 feet below, the sea could be dimly seen. About 10 feet down this crevice, which was about 2 feet wide at the top; a large stone was firmly wedged, and on it the pigeon's nest, containing a half-grown young bird and an egg, suspended, as it were, in mid-air.

26. Red Grouse (*Lagopus Scoticus*).—Several attempts have been made to introduce the red grouse into Shetland, but all without success. The first, as far as I can learn, took place about 1858, when Mr D. D. Black of Kergord, at the head of Weisdale Voe, imported a number, at the same time planting a large quantity of Norway firs (said to have been as many as 40,000), to afford shelter to the birds. As usual, however, the trees died, and the grouse gradually disappeared; a few breeding in the locality, however, for a number of years, as about 1872 three young birds were brought to the late Dr Scott of Melby, which had been caught by a woman on Sandness Hill. The distance from Kergord in a direct line to this locality is about 12 miles. Since that date nothing more has been heard of Mr Black's importation. The next attempt was made in 1882 by John Harrison, Esq. of Windhouse, in Yell, who got a consignment of about 40 sent over from Scotland. Unfortunately, however, all died in transit except one pair, which nested. Next year Mr Harrison procured five other pairs, and in 1885 the number of grouse in the islands was three coveys in Yell, one in Unst, and one in Northmavine. They seem to be quite extinct now, however, for the latest information I can gather

brings them up to the year 1886, since which time they have not been heard of. I will give the last occurrence in my informant's (James Laurenson) own words—"Last year, while in the island of Unst, I came across a boy who had found in the previous year (1886) a nest containing six eggs, and being anxious to get young ones, he watched the nest from week to week until six weeks had elapsed, when, as there were no signs of the birds coming out, he went one night and secured the mother and the eggs. Strange to say, the hen continued to sit on the eggs, even in captivity, until she died. It is needless to add that the eggs were rotten—probably for want of a male bird." Mr Harrison puts the cause of failure to the abundance of vermin, but I cannot quite agree with him in this. By the burning of the heather, not in strips but all over, the grouse are deprived of shelter in bad weather and protection from the so-called vermin, and the dense population, wet and stormy springs, and perhaps, too, the small scale on which the introduction has been tried, are all of them important factors in the failure. This failure, however, is not without its compensations to naturalists, when we consider what the establishment of the grouse and its protectors with gun, trap, and poison would have meant to many interesting Shetland birds.

27. Quail (*Colurnia vulgaris*).—One instance of the nest-



30. Lapwing (*Vanellus cristatus*), (Tieves Nachet).—Saxby says: "Now (1870) it is quite a common bird throughout Shetland." So far as Unst is concerned, this is quite true, but in many districts of the mainland and on other islands the pewit is unknown. Its greater abundance in Unst is doubtless due to the greater amount of cultivation on that island. The only two places on the west coast of Mainland at which I observed this bird were at Hillswick and Walls. At the former one pair, and at the latter four pairs, were nesting. An old inhabitant of Walls informed me that they first appeared in the district about twenty years ago, so that the species is probably still extending its range in the islands. It occurs in some numbers in the Tingwall Valley.

31. Turnstone (*Strepsilas interpres*), (Stanepecker).—There is no doubt a pair of these birds occasionally remains to breed in Shetland. Thomas Edmondston considered them resident; and Saxby, after long and patient watching, found a nest with three eggs at Widwick in Unst, which is the only record, as far as I am aware. On the 27th May 1887, I saw a single bird on the shore a few miles south of Lerwick, but from its behaviour evidently not breeding.

32. Oystercatcher (*Hæmatopus ostralegus*), (Shellder).—The oystercatcher is common on many parts of the coast, but not very numerous at any one place, though a pair or two are to be found on most of the points. On the little islands lying off shore they are perhaps most abundant. The eggs are sometimes very badly concealed, as, for instance, when placed, as they often are, in a hollow scooped in the green turf on the edge of the cliff.

33. Heron (*Ardea cinerea*), (Haigrie).—Very rarely remains to breed. Saxby once obtained the eggs from a nest placed among rocks at Whiteness on Mainland.

34. Curlew (*Numenius arquata*), (Whaup, Stock-whaup).—Occurs sparingly on the mainland. I saw very few of these birds, and they were very wary, in marked contrast to the following species.

35. Whimbrel (*Numenius phæopus*), (Tangwhaup, Peerie-whaup).—These birds are not numerous, and are confined to a few of the wildest and most thinly inhabited parts. In one

district several pairs were remarkably tame, running along the ground only about thirty yards ahead; but though, from their behaviour, evidently breeding, I failed to find a nest. The cry is a good deal like that of a curlew, but possesses quite distinct characteristics.

36. Redshank (*Totanus calidris*).—According to Saxby a few pairs breed. I did not meet with it.

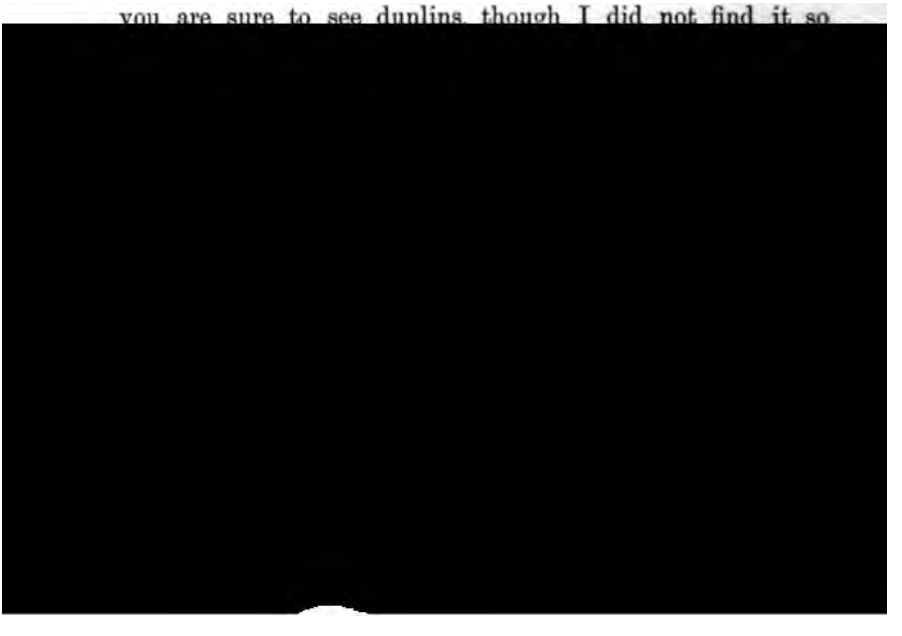
37. Sandpiper (*Totanus hypoleucos*).—"On 2d July 1869, Robert Mouat not only shot a pair at the Loch of Cliff, but had a chase after the young (Saxby, p. 195). This is the only evidence of its nesting I have been able to find.

38. Greenshank (*Totanus glottis*).—"Occasionally breeds" (Saxby, p. 196).

39. Woodcock (*Scolopax rusticola*).—"Has nested occasionally" (Saxby).

40. Snipe (*Scolopax gallinago*), (Gowk, Snippack).—I did not find the snipe nearly so common on Mainland in 1887 as on a former occasion in Unst. Still they were abundant in most places, and exceedingly tame, running along the ground a few yards ahead.

41. Dunlin (*Tringa alpina*), (Ploverpage, Jacksnipe).—The local name "ploverpage" describes the dunlin's habits with great accuracy, for wherever there are golden plovers you are sure to see dunlins, though I did not find it so



44. Mallard (*Anas boschas*), (Wild Duke).—Sparingly scattered in most localities, sufficiently remote from houses to give the ducks a chance of getting off a brood. On 28th May 1887, I overtook a duck with a brood of nine travelling along the road near Skierda Loch. They were, though apparently newly hatched, wonderfully active, and concealed themselves among the heather with great dexterity.

45. Teal (*Querquedula crecca*).—A few pairs only remain to breed, and they seem most numerous in the Walls district of Mainland.

46. Widgeon (*Anas penelope*).—Much the same may be said of the widgeon as of the teal. I saw several ducks which I took to be of this species in Walls.

47. Eider (*Somateria mollissima*), (Dunter).—The eider is sparingly scattered round the coast of Mainland; the only place where I saw them in numbers was round the Fugla and Lyra Skerries, off Papa-Stour. In the sea between Stour and these islets I saw between sixty and seventy, nearly all males, and found a nest with two eggs on a point opposite them. The people informed me that great numbers of dunters bred on these skerries, one of which, Lyra, is exceedingly inaccessible, only two men on Stour being able to scale it. On a tall stack here the whitetailed eagle bred some years ago.

48. Redbreasted Merganser (*Mergus serrator*), (Hareld Duck).—In districts where there is a number of lochs this beautiful bird may be constantly seen. It particularly favours those lochs which possess small rocky islets, sometimes covered with low bushes and dwarf trees (ash, birch, and rowan).

49. Redthroated Diver (*Colymbus septentrionalis*), (Rain Goose).—There are still a few pairs of this interesting species nesting among the pools in the most secluded parts of Mainland. These birds are usually very wary, but on two occasions I surprised the female on the nest. On the first occasion the nest was placed on the edge of a small pool, about fifteen yards in diameter, and the bird rose on the wing directly off the eggs, splashing heavily right across the surface of the water before getting fairly launched on the wing. On the other, the

bird when first seen was lying on her egg, which was placed on the bank of a loch about two hundred yards long. Contrary to the usual custom, this nest was about two feet above, and a couple of yards away from the water. On catching sight of me the old bird immediately struck out vigorously with her feet, shoving herself along on her breast till it touched the water, when she immediately vanished without the least splash, and only reappeared near the other end of the loch. The eggs are of two strongly-marked types. One has the ground colour rich reddish brown, the other olive green; occasionally a spotless clay-coloured egg may be met with.

50. Common Guillemot (*Lomvia troile*), (Longie).—At the few large breeding stations this bird occurs in enormous numbers. The three largest of these are Unst, Foula, and Noss, and at each of them the numbers amount to many thousands. On Papa-Stour, and on the Ramna Stacks, off Fiedeland Point, there are smaller colonies. I visited one of these latter on the 31st May, and found it crowded with birds. The stack is a small one, merely a pinnacle of rock about 150 feet high, and 80 or 90 feet in diameter, and destitute of ledges or a particle of vegetation, but is covered from about half-way to the summit with broken masses of rock, thus providing numerous chinks and crevices for the shelter of the birds, every one of which crevices was swarming with

scratching with vigour. The only sound they give vent to is a low croak. On throwing up a razorbill from the highest pinnacle, it fell straight down for about thirty feet before getting itself under command.

51. Black Guillemot (*Uria grylle*), (Tystie).—The tystie is one of the most characteristic Shetland birds, and may be seen in small parties all round the coast. I saw a pair diving away in their active fashion, at the Knab, about a mile from Lerwick. The nests are rather difficult to find, as they do not form extensive colonies, but a pair, or a few pairs, breed at many different places. They used to frequent the islands in the Bay of Scalloway in some numbers, but have much decreased of late, being shot in the autumn by tourists and fishermen, their confiding nature rendering this an easy task. The fishermen, for what reason I cannot conceive, seem to have a great desire to kill this beautiful little bird, taking every opportunity they can to do so. These birds breed late ; a nest I got on the Cheynies on 15th June contained only one egg fresh. [*Note.*—Since writing the above, Mrs Jessie M. E. Saxby has kindly suggested to me a reason for the dislike of the Shetlanders to the tystie. It is this—The old men, women, and children frequently fish for " Piltocks " off rocks projecting into the water, and occasionally fatal accidents occur at these places. The tystie is very fond of diving and swimming among the broken water at such spots, and has in this way come to be associated with calamity in the minds of the islanders.]

52. Puffin (*Fratercula arctica*), (Tammy Norie).—This is one of the most abundant birds in Shetland, breeding in many thousands at a few favourite stations, such as Noss, Unst, and Foula. On the Island of Grüney, off Fiedeland Point, there is a small colony of 300 or 400 pairs. These only migrated to this island a few years ago, having previously nested on a stack farther out ; but what with their burrows, and the people breaking up the turf to get at them and their eggs, the soil almost entirely disappeared from the stack, being quickly blown away when once loose, by the terrific gales that rage round these lonely pinnacles. This same process is going on at the present colony, but Grüney,

being of some extent, is not likely to drive the puffins to seek pastures new for some time. There being no rabbits on the island, the puffins dig all the burrows themselves. In one of the burrows near the cliff edge I was somewhat surprised to find a razorbill's egg.

53. Razorbill (*Alca torda*), (Wilkie).—As elsewhere, this bird seems to be much less numerous than the guillemot at their common breeding haunts. The razorbill is usually said to lay rather apart from the guillemot, but on the Ramna Stacks this is not so, probably owing to the guillemots being forced to adopt the nesting habits of the razorbill.

54. Cormorant (*Phalacrocorax carbo*), Loering, Scarf (adult), Brongie (young).—The cormorant is not very common in Shetland. A few may be seen at many places, but in very small numbers compared with the shag. On the Fiedeland stack I visited, there were only three pairs of this bird among a considerable number of shags. The eggs are as a rule larger than the shag's, but often very slightly so, exceptionally large shags equalling them in size. They breed early, even in Shetland. A man showed me three young ones on the 31st May, which he had taken from the Fiedeland stacks. They were then fully a week old, which would place the laying about the middle of April.

56. Arctic Tern (*Sterna macrura*), (Tirrock).—This lively and beautiful little tern is generally diffused throughout the whole archipelago, usually nesting on the small islands lying off shore. One such situation, where I am told it is very abundant, is the Ve Skerries, about four miles north-west of Papa-Stour. Ve comes from a Norse word signifying danger, and the skerries (which are a great haunt of the "Haaf fish"—*Halichærus gryphus*) have the reputation of seldom belying their title. No doubt the natives are in the habit of exaggerating the inaccessibility of these places, but I think it is little exaggerated in regard to these rocks. The small islands in the Bay of Scalloway are a favourite haunt. At West Loch, in Hildasay, there was a colony of about 100 pairs, and on all the other islands a few. They breed very late; on the 15th of June they had only begun to lay. [*Note.*—The Common Tern (*S. fluviatilis*) has not, so far as I am aware, been yet detected in Shetland.]

57. Black Tern (*Hydrochelidon nigra*).—One record of this bird's occurrence in Shetland, which will be found on p. 446 of the *Zoologist* for 1844, is the only one known to me. This record is by Thomas Edmondston.

58. Black-headed Gull (*Larus ridibundus*).—This is the rarest of the resident gulls in Shetland, according to Edmondston and Saxby a few pairs only nesting at one or two localities. Edmondston says ("View of the Zetland Islands," p. 284): "A few pairs of this gull come regularly every year to Zetland during the breeding season. They frequent the flat, gravelly shores of deep bays, appear familiar, and are very seldom molested." I did not observe this species, but Mr Scott of Melby informs me that he sometimes sees a few in the summer.

59. Kittiwake (*Rissa tridactyla*), (Waeg).—The graceful kittiwake is exceedingly abundant in Shetland, collecting during the breeding season at some half-dozen colonies, at several of which their numbers are to be counted by thousands, if not tens of thousands. Unst, Foula, and Noss are the chief stations. At the latter the sandstone escarpments from 50 feet above sea-level up to 300 feet out of the total height of 592 feet are covered with the kittiwakes and their nests. On one of the Ramna Stacks there is a small colony

of between 300 and 400 pairs, which I visited on the 31st May 1887. The kittiwake is a late breeder. At that date only a few had laid; the majority were busily engaged upon their nests, or chasing each other with shrill screams. They were, at this little visited spot, exceedingly tame, several allowing me to stroke them on the back with the short rod I carried (the two butt joints of an ordinary fishing-rod), and this when the nests, by the side of which they stood, were empty. The nests of the kittiwake are almost invariably exceedingly difficult of access, from the shape of the rocks on which these were built it would be utterly impossible to get many of the nests even with a rope. There is another fine colony of these birds on Eshaness Skerry, near Hillswick and also a small one of 60 or 70 pairs on Papa-Stour, at the entrance to one of the magnificent caves for which that island is famous.

60. The Common Gull (*Larus canus*), (Blue Maa) is by no means common on the mainland. On some of the small islands a little way off from the land, there are small colonies, but at no place do they ever nest on cliffs, like the herring and lesser black-backed gulls. On the lochs of Walls there are one or two pairs usually on each of those lochs which have little islands in them, and often a single pair at many

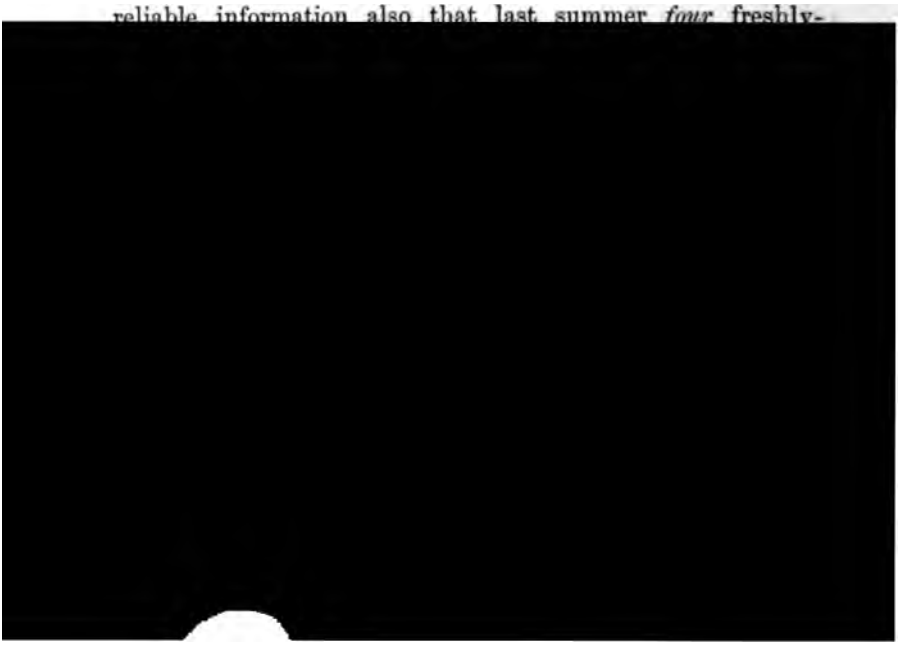
inland district, where this gull is most abundant, is the network of lochs lying to the south of Melby, in the parishes of Walls and Nesting. On these lochs, including the loch of Collaster (250 pairs), there are fully 600 pairs. Hewitson fell into the error of describing the Collaster gull as the greater black-back, but that bird never bred there, nor does it on any of the lochs of Walls. On the island of Noss there is a colony of *L. fuscus* nesting on the ground among some peat hags. At the date of my visit (17th June) there were only 50 or 60 pairs, and at that late date I saw several nests containing fresh eggs, but the people at Noss Ferry said that earlier in the season they were "in hundreds." They had doubtless left in despair of getting any eggs hatched.

62. Herring Gull (*Larus argentatus*), (White Maa).—Exceeding abundant. Every precipitous headland is sure to be occupied by a colony of these handsome birds. On the island of Noss they are very numerous. I estimated them at upwards of 1000 pairs, and from their habit of nesting on the ledges of the cliffs, and on the almost perpendicular grass slope to the east of the Noup, they do not suffer so much persecution as the lesser black-backs on the turf inland.

63. Greater Black-backed Gull (*Larus marinus*), (Swabie, Baagie).—Single pairs of these magnificent gulls may be seen at many parts of the coasts. A favourite site for the nest is the flat grassy summit of some tall stack, often entirely inaccessible. Frequently the stack is shared with the two smaller species—*fuscus* and *argentatus;* all three getting on pretty well together as a rule, though *marinus* is rather inclined to bully. The largest colony of these birds in Britain is that situated on the Holm of Noss. The Holm is a detached portion of the island of Noss, and is about 200 feet high, and quite inaccessible since the "cradle" was removed a few years after Professor Wilson's visit in 1841, so graphically described by the genial "Christopher" in his "Voyage." It is about 1½ acres in extent, and the chasm between is about 50 yards across. On approaching the edge of the cliff, the whole colony rises on the wing at once, and an accurate estimate of their numbers is rather difficult to take, but I came to the conclusion there cannot be less than 250 pairs of these huge birds (5½ feet in extent of wing) at this place.

A few lesser black-backs and one or two herring gulls also breed on the "Holm." The young on the 17th of June would be pretty well grown, as this gull breeds early, the first eggs being frequently laid by the 2d of May. I found fresh eggs at Fiedeland on the 31st May, but these were of a second laying. A nest I reached on the 2d June at Uyea contained two newly-hatched young and an egg just chipping. Both old birds in this case were very bold, the female especially. As I climbed down the cliff, I frequently felt the wind from her wings as she swooped past my head with her deep barking note, huc—huc—huc.

64. Great Skua (*Stercorarius catarractes*), (Bonxie).—This is *the* bird of Shetland; its breeding stations in the British Isles being confined to only three localities—all in Shetland. The number of pairs that still nest in these localities is small, and, I fear, still decreasing, though the skuas of Unst seem to have held their ground wonderfully well for the last twenty-five years. Foula has been for many years the chief stronghold of these birds, and Mr Scott of Melby, the proprietor, informed me that there are still sixteen pairs there. Although strict orders have been given that the birds are not to be interfered with, a good many of their eggs are annually taken and sold to English dealers. I have reliable information also that last summer *four* freshly-



Mackay found the skuas sitting in September, this being their third attempt to raise a brood. It seems a pity that more stringent measures cannot be taken for the skuas' protection. The shepherd does what he can, but of course cannot be everywhere at once. If relieved from persecution they would soon increase, as their smaller relation, the Arctic Skua, has done in the same locality. A third locality, where I discovered a single pair nesting in 1885, was again tenanted this year (1887). I saw both birds at a hillock about two miles from the nest site of 1885, but they were not aggressive, as is their habit when they have eggs, but were simply indifferent, sitting stolidly until I walked up to within eight paces, when they merely shifted to the next hillock. From their behaviour, it was evident the nest had been robbed, and I afterwards saw the man who had found the nest, with a single egg, on the 20th May. We may thus reckon the total number of these fine birds that still nest in these islands at about twenty pairs.

65. Richardson's Skua (*Stercorarius crepidatus*), (Allan, Shooi).—There are several considerable colonies of the Arctic skua throughout Shetland. The largest is that at the haunt of the great skua in Unst. At the date of my visit to Unst (1885), the colony only numbered thirty pairs, and were decreasing rapidly, their eggs being taken in quantities and sold to an English dealer, but this having been discontinued, they are now increasing rapidly. A letter I received this year from Mr Mackay states—"I can safely say there were from 80 to 100 pairs here last season (1887). There is a colony on the mainland of about twenty-four pairs. As this colony is in a very secluded district, and much scattered, it will probably hold its own for some time yet. There are also colonies of about fifty pairs in Noss, and thirty pairs in Foula, besides scattered pairs in a good many other islands. This skua is not altogether an agreeable neighbour to the other seafowl, and I was eye-witness of an incident which doubtless often occurs at their colonies. There were a number of lesser black-backs nesting among the skuas, and I saw one of the latter, despite the valiant efforts of the gull to protect its nest, and the terrible outcry raised by the

others, swoop down upon the nest, gash the egg across with its beak, and proceed to devour the contents.

66. Fulmar Petrel (*Procellaria glacialis*), (Mallemoke).—In the *Zoologist* for 1879, p. 380, there appeared a letter from a Mr Garriock, of Lerwick, stating that, on the 4th June 1878, a party of about a dozen pairs of fulmars had formed a colony on the most inaccessible cliff of Foula. This colony increased next year to about twenty pairs, and I am informed by Mr Laurenson that it is still in existence. The position chosen seems to be very inaccessible, for Mr Laurenson states that very few eggs have ever been got. This is an exceedingly interesting example of a recent extension of range of this bird.

67. Manx Shearwater (*Puffinus anglorum*), (Lyrie).—This bird is not often seen, and is confined to a few localities, of which Yell, Unst, and Foula are the chief. In Unst it is apparently scarcer than it used to be a few years back. Saxby expresses the opinion that this bird produces two broods in the season; probably from the fact that fresh eggs may be found from the beginning of May to the end of June, but I think there is no foundation for this belief.

68. Storm Petrel (*Thalassidroma pelagica*), (Swallow, Spencie).—The "swallow," as they call this pretty little bird at Oxna, is a very late breeder, and does not arrive at that island until the last few days of June. Almost immediately

JOURNAL OF PROCEEDINGS.

SESSION CXV.

Wednesday, 18th November 1885.—B. N. PEACH, F.R.S.E., President, in the Chair.

An Opening Address was delivered by the President on "Some of the Relations of Palæontology to Geology, illustrated chiefly by Examples from the Scottish Rocks."

Wednesday, 16th December 1885.—Professor DUNS, D.D., F.R.S.E., Vice-President, in the Chair.

The following Office-Bearers were elected :

President—Professor WILLIAM TURNER, LL.D., F.R.S.

Vice-Presidents—JOHN A. HARVIE-BROWN, F.R.S.E., F.Z.S.; Professor JOHN DUNS, D.D., F.R.S.E. ; Professor J. COSSAR EWART, M.D., F.R.S.E.

Secretary—ROBERT GRAY, V.P.R.S.E. *Assistant-Secretary*—JOHN GIBSON.

Treasurer—CHARLES PRENTICE, C.A., F.R.S.E.

Librarian—WILLIAM EVANS HOYLE, M.A., F.R.S.E.

Councillors—John Hunter, F.C.S.; Robert Kidston, F.G.S. ; A. M. Herbert ; Professor James Geikie, LL.D., F.R.S. ; G. Sims Woodhead, M.D., F.R.C.P.Ed.; Hugh Miller, F.G.S., A.R.S.M.; Arthur W. Hare, M.B., C.M. ; R. Milne Murray, M.A., M.B., M.R.C.P.E. ; H. Moubray Cadell, B.Sc. ; R. H. Traquair, M.D., F.R.S. ; R. Sydney Marsden, D.Sc., F.R.S.E., F.C.S. ; B. N. Peach, F.G.S., F.R.S.E.

The following gentlemen were elected Ordinary Fellows of the Society : G. Lovell Gulland, M.A., B.Sc. ; T. Arthur Helme, M.B., C.M. ; George Brook French, M.R.C.S. ; R. F. C. Leith, M.A., M.B., B.Sc. ; Wm. Hunter, M.B., C.M. ; J. Barker Duncan, W.S. ; Henry T. Tomlinson, M.B., C.M.

The following communications were read :

1. "On the Species of the Genus *Palæoxyris*, Brong., occurring in British Carboniferous Rocks." By ROBERT KIDSTON, F.G.S.
2. "On the Hatching of Herring in Deep Water." By Professor EWART, F.R.S.E.
3. "Notes on the Sucker Fishes, *Liparis* and *Lepadogaster*." By W. ANDERSON SMITH, of Ledaig. (Communicated by J. T. Cunningham, B.A.)
4. "On the Nature of Segmentation in Fish Ova." By GEORGE BROOK, F.L.S.
5. "On the Sense of Touch in *Astacus*." By G. L. GULLAND, M.A., B.Sc.

Wednesday, 20th January 1886.—Professor TURNER, F.R.S., President, in the Chair.

The following gentlemen were elected Ordinary Fellows of the Society: George James M'Carthy Melle; J. C. Lamont, M.B., M.R.C.S.; James Haig Ferguson, M.B., C.M., M.R.C.S.; Arthur Dendy, B.Sc.; William A. Turner.

The following gentlemen were elected Honorary Fellows of the Society: Henri de Lacaze Duthier; P. J. van Beneden.

The following communications were read:

1. "Obituary Notice of Dr William Carpenter, F.R.S." By Professor J. COSSAR EWART.
2. "On the Occurrence of the Bottle Nosed or Beaked Whale (*Hyperoodon rostratus*) in the Scottish Seas; with Observations on its external Characters." By Professor WILLIAM TURNER, LL.D., F.R.S., President.
3. "On the Relation of Yolk to Blastoderm in the Fish Ovum." By GEORGE BROOK, F.L.S.
4. "On an Abnormal Specimen of *Comatula* from the Firth of Clyde." By ARTHUR DENDY, B.Sc.
5. "Journal of Ornithological Observations made in the Shetland Islands in June 1885." By HAROLD RAEBURN.
6. Exhibition of specimen of the Glossy Ibis (*Ibis falcinellus*, ♂) shot at Mindrim, on the borders of Roxburghshire, on 25th August last; also a specimen of the Garganey (*Querquedula circia*) shot at Foulden, Westmains, Berwickshire, in February 1885. With Remarks. By GEORGE MUIRHEAD.

Wednesday, 17th February 1886.—Professor JOHN DUNS, D.D., F.R.S.E., Vice-President, in the Chair.

The following gentlemen were elected Ordinary Fellows of the Society:

Wednesday, 17th March 1886.—JOHN A. HARVIE-BROWN, F.R.S.E., F.Z.S., Vice-President, in the Chair.

The following gentlemen were elected Ordinary Fellows of the Society: William Horne, Advocate; R. Charles MacWatt, M.B., C.M.; John Edward Harry Kelso, M.B., C.M.; James M. Campbell, M.A.; A. H. F. Barbour, M.A., B.Sc., M.D.

The following communications were read:

1. "On the Reproduction of Lost Parts in the Lobster." By GEORGE BROOK, F.L.S.
2. "A Synopsis of recent Cephalopoda." By WM. E. HOYLE, M.A.
3. Dr TRAQUAIR exhibited, with remarks, a specimen of *Cryphiolepis striatus*), an unfigured fossil fish from Loanhead.
4. "Note on the Shore Crab (*Carcinus mænas*)." By Professor JOHN DUNS, F.R.S.E., Vice-President.
5. "On the Occurrence of the Great Snipe (*Scolopax major*) near Glasgow in May 1885." (Specimen exhibited, ♂.) By WM. EVANS, F.R.S.E.
6. Exhibition of two specimens of the Marten (*Martes foina*), ♂ and ♀, caught last month in Inverness-shire (Eastern division). By JAMES M. ANDERSON.
7. Mr EVANS exhibited, with remarks, a ♂ specimen of the Stockdove, shot on 6th January last near Longniddry, East Lothian.
8. Mr GRAY drew the attention of the meeting to two Albino Hedgehogs, adult and young, which had been forwarded for exhibition by the Earl of Haddington.
9. Mr BROOK exhibited a tall mass of seaweed covered with Herring Spawn, and made some remarks, showing that the spawn had been shed at some distance from the sea bottom. The specimen was obtained from the Ballantrae fishing grounds.
10. Mr PEACH exhibited specimens of the claws of *Nephrops norvegicus*, showing departure from the ordinary structure.

Wednesday, 21st April 1886.—Professor JOHN DUNS, D.D., F.R.S.E., Vice-President, in the Chair.

The following gentlemen were elected Ordinary Fellows of the Society: Alexander Shaw; Ernest Robertson, M.B., C.M.; A. A. Murdoch; John Moody Stuart.

The Librarian gave notice of the following motion, to be discussed at next ordinary meeting: "In Rule VII., paragraph 5, before the word 'Fellows,' insert 'such,' and after the same word insert 'as pay an additional annual subscription of 2s. 6d.'" That portion of the rule will then read—"The Librarian shall lend out books to such Fellows as pay an additional annual subscription of 2s. 6d."

The following communications were read:

1. "On three Specimens of Cyclopean Monsters—Human, Pig, Sheep." By JOHNSON SYMINGTON, M.D., F.R.S.E., and G. SIMS WOODHEAD, M.D., F.R.S.E.
2. "On the Occurrence of Spores in the Carboniferous Formation of Scotland." By ROBERT KIDSTON, F.G.S., and JAMES BENNIE.

3. "Synopsis of the British Paguridæ." By Professor J. R. HENDERSON.
4. "Contributions to a Bibliography of the Sea Serpent." By WM. EVANS HOYLE, M.A.
5. Dr TRAQUAIR exhibited a specimen of *Lumpenus lampetræformis* (Walb.) from Aberdeen.
6. Mr EVANS exhibited, with remarks, a specimen of the White Wagtail (*Motacilla alba*) from Dunbar.

SESSION CXVI.

Wednesday, 17th November 1886.—JOHN A. HARVIE-BROWN, F.R.S.E., Vice-President, in the Chair.

The Librarian proposed the change in Rule VII., according to notice given at last ordinary meeting, and the motion was carried.

The following gentlemen were elected Ordinary Fellows of the Society: George A. Panton, F.R.S.E.; John M. Cadell, M.B., C.M.; George E. C. Wood, M.B., C.M.; C. J. Lewis, M.B., C.M.; Professor William M'Cracken.

An Opening Address was delivered by the Chairman on "The Isle of May: its Faunal Position and its Bird Life."

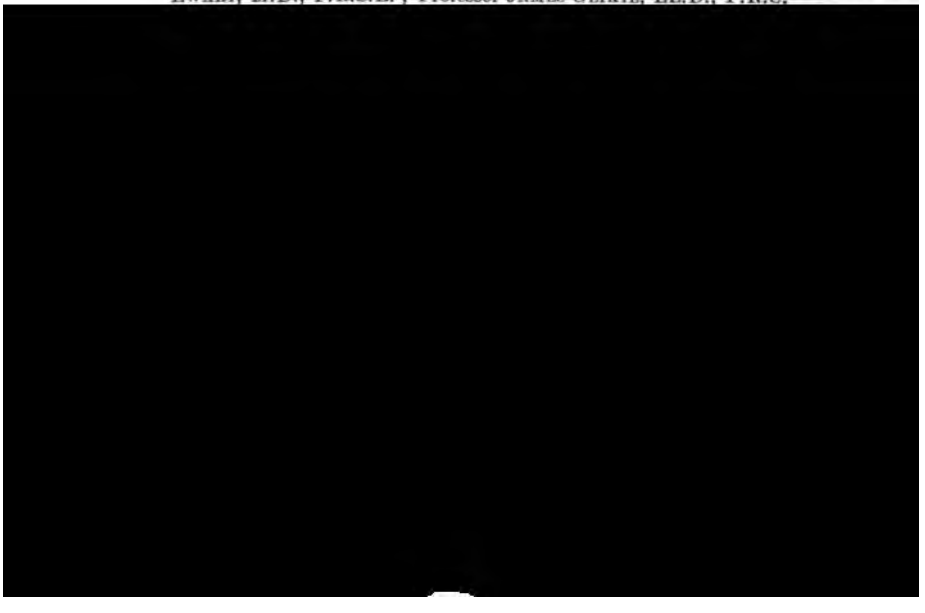
Wednesday, 15th December 1886.—Professor JOHN DUNS, D.D., F.R.S.E., Vice-President, in the Chair.

Reports were submitted by the Secretary, the Treasurer, and the Librarian.

The following Office-Bearers were elected:

President—Sir WILLIAM TURNER, LL.D., F.R.S.

Vice-Presidents—Professor JOHN DUNS, D.D., F.R.S.E.; Professor J. COSSAR EWART, M.D., F.R.S.E.; Professor JAMES GEIKIE, LL.D., F.R.S.



(3.) A specimen of the Great Spotted Woodpecker from the Isle of May, with records of the occurrence of this species in the Pentland Skerries and elsewhere.

2. "Preliminary Notes on the Chætopoda of the Firth of Forth." By J. T. CUNNINGHAM, B.A., F.R.S.E.
3. "List of Echinodermata from the Firth of Clyde." By Prof. HENDERSON.
4. "Notes on the British Species of *Zeugopterus*." By GEORGE BROOK, F.L.S.
5. Exhibition of Fossil Ferns belonging to the genus *Rhacophyllum*. By ROBERT KIDSTON, F.G.S.
6. Mr HOGG exhibited (1.) a hybrid between the Common Pheasant and Reeves' Pheasant; and (2.) a female Black Grouse assuming the plumage of the male.
7. Mr EVANS exhibited a specimen of an adult male Blue-throated Warbler (*Cyanecula Suecica*), which was shot at Belhaven, near Dunbar, in end of May or beginning of June 1868.

Wednesday, 19th January 1887.—Dr SYMINGTON in the Chair.

The following gentlemen were elected Ordinary Fellows of the Society: J. Houston Barry; Robert Howden, M.B., C.M.; William Somerville of Cormiston; James Duncan; P. Caradoc Williams.

The following communications were read:

1. "Notes on some newly-described Tracts in the Spinal Cord." By ALEXANDER BRUCE, M.A., M.B., F.R.S.E.
2. "Revision of the Nomenclature of the Fishes of the Old Red Sandstone. Part I., *Acanthodidæ* and *Palæoniscidæ*." By R. H. TRAQUAIR, M.D., F.R.S.
3. "Report on the Collection of Shells made by Mr John Rattray on the West Coast of Africa, the Canaries, and Cape Verde Islands;" with exhibition of specimens. By W. E. HOYLE, M.A., F.R.S.E.
4. Exhibition of specimens of *Bothriocephalus proboscideus* and *Ascaris clavata*, with remarks. By W. E. HOYLE, M.A., F.R.S.E.

Wednesday, 16th February 1887.—Professor JOHN DUNS, D.D., F.R.S.E., Vice-President, in the Chair.

The following gentleman was elected an Ordinary Fellow of the Society: Symington Grieve.

The following communications were read:

1. "On a recently-described Method of determining the presence of *Ptomaines* in Growths of Micro-Organisms." By G. SIMS WOODHEAD, M.D.
2. "Remarks on a Coralline from Gran Canaria." By JOHN RATTRAY, M.A., B.Sc.
3. "Notes on the relation of Pelagic Fauna to our Inshore Fisheries." By GEORGE BROOK, F.L.S.
4. Exhibition of a specimen of the Bittern (*Botaurus stellaris*) shot at Longniddry on 5th January last. By WILLIAM EVANS, F.R.S.E.
5. "Exhibition of an Indian Water-snake (*Enhydrina valakadyen*) killed by swallowing a Siluroid Fish." By J. E. H. KELSO, M.B., C.M.

Wednesday, 16th March 1887.—Professor Sir WILLIAM TURNER, President, in the Chair.

The Chairman announced that, owing to the death of Mr Robert Gray, the Council had appointed Dr R. H. Traquair as Interim Secretary until the next annual meeting.

The following minute of condolence, which had been forwarded by the Council to Mrs Gray, was approved by the Society :—

"The Council of the Royal Physical Society herewith records its deep sense of the very serious loss which the Society has sustained by the death of its Secretary, Mr Robert Gray.

"Few men, if any, could be found whose natural gifts presented so rare a combination of all the qualities desirable in an efficient Secretary,—no one who would more enthusiastically and unselfishly have devoted his time and his energies to a task whose only reward could be the consciousness of having benefited others.

"During the ten years of Mr Gray's tenure of office as Secretary, the Royal Physical Society rose from a comparatively languishing state to one of new life and prosperity ; and there can be no doubt that this result was principally due to his business talent, to his unflagging energy, to the wide range of his scientific sympathies, to his high reputation in his own particular branch of Natural History, to his sterling integrity of character, and to his unfailing amiability of disposition, which secured him the support and co-operation of all who were interested in the welfare of the Society.

"*Feby.* 28*th*, 1887. (Sigd.) WM. TURNER, *Præses.*"

The following gentlemen were elected Ordinary Fellows of the Society : E. Albert Sturman, M.A., LL.D.; Charles Alexander MacMunn, M.A., M.D.; Alexander Goodman More, F.Z.S., M.R.I.A.; John Gunn ; George J. Dundas ; H. C. Corke, F.R.S.E. ; R. M. Ferguson, M.D.

2. "Notes on the Occurrence in Scotland of the Great White Heron (*Ardea alba*) and the Blue-winged Teal (*Querquedula discors*);" with exhibition of specimens. By R. H. TRAQUAIR, M.D., F.R.S.

   The Heron was shot at Branechoil, Loch Katrine, in May 1881, and recorded in the *Scottish Naturalist* for 1886 (p. 367) as a Little Egret. The Teal was shot on the Nith, Dumfriesshire, about 25 years ago (*vide* Gray's "Birds of West of Scotland," p. 373). Both are now in the Edinburgh Museum of Science and Art.

3. "On the Development of the Oviduct in Teleostean Fishes." By J. T. CUNNINGHAM, B.A.

SESSION CXVII.

Wednesday, 16th November 1887.—Professor JOHN DUNS, D.D., Vice-President, in the Chair.

The following gentlemen were elected Ordinary Fellows of the Society: Oswin A. J. Lee; John S. Oliver; J. Arthur Thomson.

The Chairman delivered an Opening Address, paying a tribute to the memory of Fellows deceased since the beginning of last Session, referring to the present state and future prospects of the Society, and criticising the attitude of several leading Darwinians towards Darwin's Theory.

Wednesday, 21st December 1887.—Sir WILLIAM TURNER, President, in the Chair.

The Secretary submitted a Report on the state of the Society; the Librarian on the state of the Library; and the Treasurer on the state of the Accounts.

The following Office-Bearers were elected:

President—Sir WILLIAM TURNER, LL.D., F.R.S.

Vice-Presidents—Professor J. COSSAR EWART, M.D., F.R.S.E.; Professor JAMES GEIKIE, LL.D., F.R.S.; G. SIMS WOODHEAD, M.D., F.R.S.E.

Secretary—R. H. TRAQUAIR, M.D., F.R.S. *Assistant-Secretary*—JOHN GUNN.

Treasurer—GEORGE LISLE, C.A.

Councillors—H. Moubray Cadell, B.Sc., F.R.S.E.; B. N. Peach, F.G.S., F.R.S.E.; George Brook, F.L.S.; William Evans, F.R.S.E.; Professor Wallace, F.R.S.E.; Johnson Symington, M.D., F.R.S.E.; John Falconer King, F.C.S.; J. A. Harvie-Brown, F.R.S.E.; Professor Duns, D.D.; G. Lovell Gulland, M.A., M.B.; R. Kidston, F.G.S., F.R.S.E.; T. B. Sprague, F.R.S.E.

The following gentlemen were elected Ordinary Fellows of the Society; William Russell, M.D., F.R.C.P.E.; E. Wearne Clarke, B.Sc., M.B., C.M.; Samuel W. Wallace.

The following communications were read:

1. "On some points in the Anatomy of the Flat Worms." By WM. E. HOYLE, M.A., F.R.S.E.

2. "Synthetic Summary of the Influence of the Environment upon the Organism." By J. ARTHUR THOMSON, M.A., F.R.S.E.
3. "Notes on the Marine Crustacea of the Clyde Estuary." By GEORGE BROOK, F.L.S., and THOMAS SCOTT.
4. "An Ornithological Visit to the Ascrib Islands." By JOHN SWINBURNE.
5. Mr EVANS, on behalf of Mr DUNDAS, exhibited Skins of the Fulmar and of the Little Gull, both obtained in the Firth of Forth, near North Berwick, in October last.

Wednesday, 18th January 1888.—Dr G. SIMS WOODHEAD, Vice-President, in the Chair.

The following gentlemen were elected Ordinary Fellows of the Society: T. Wemyss Fulton, M.B., C.M.; James Foulis, M.D., F.R.C.P.E.

The following communications were read:

1. "On the Structure of the Graafian Follicle in *Didelphys*." By F. E. BEDDARD, M.A., F.R.S.E.
2. "Notes on Carboniferous *Selachii*." By R. H. TRAQUAIR, M.D., F.R.S.
3. "Notes on a visit to Fernando Noronha." By GEORGE H. RAMAGE. (Communicated by John Gunn.)

Wednesday, 15th February 1888.—Dr G. SIMS WOODHEAD, Vice-President, in the Chair.

The following gentleman was elected an Ordinary Fellow of the Society: John Corner.

The following gentlemen were elected Honorary Fellows of the Society: Professor E. R. Lankester, F.R.S.; Sydney H. Vines, M.A., F.R.S.

The following communications were read:

2. "On the Prevalence of Eurypterids in the Carboniferous Shales of Scotland." By JAMES BENNIE.
3. "Account of recent Researches into the *Siphonophoræ*;" with exhibition of Drawings. By WM. E. HOYLE, M.A., F.R.S.E.
4. Mr HOYLE exhibited, with remarks, some Specimens of Parasites from Seals and Whales.

Wednesday, 18th April 1888.—Dr G. SIMS WOODHEAD, Vice-President, in the Chair.

The following gentleman was elected an Ordinary Fellow of the Society: E. C. Stump.

The following communications were read:

1. "On the Summer Birds of Shetland, with Notes on their Nesting, Distribution, and Comparative Numbers." By HAROLD RAEBURN.
2. "Notes on the British Species of *Lepadogaster*, and on the Development of the Vertical Fins." By GEORGE BROOK, F.L.S.
3. "On the Fructification of two Coal-Measure Ferns." By ROBERT KIDSTON, F.G.S.
4. "Notes on the Fructification and Affinities of *Archæopteris hibernica*, Forbes sp." By ROBERT KIDSTON, F.G.S.
5. The SECRETARY exhibited a case of United Comminuted Fracture in the leg of a Pheasant.
6. Dr LESLIE exhibited a Peregrine Falcon of unusually pale plumage.
7. Mr KEMP exhibited specimen of a double Kitten.

LIST OF SOCIETIES WHICH RECEIVE THE SOCIETY'S "PROCEEDINGS."

Those Institutions from which Publications have been received in return are indicated by an asterisk.

ENGLAND.

BIRMINGHAM,	*Philosophical Society, King Edward's Grammar School.
Do.	*Natural History Society, Sir Josiah Mason's College.
CAMBRIDGE,	*Philosophical Society.
Do.	University Library.
CIRENCESTER,	*Editor of the *Agricultural Students' Gazette.*
DURHAM,	University Library.
HALIFAX,	*Yorkshire Geological and Polytechnic Society.
LEEDS,	*The Conchological Society of Great Britain and Ireland.
LIVERPOOL,	*Biological Society, University College.
Do.	*Literary and Philosophical Society.
Do.	*Engineering Society, Royal Institution.
LONDON,	British Museum Library.
Do.	*British (Natural History) Museum, South Kensington.
Do.	*Royal Society, Burlington House, Piccadilly, W.
Do.	Chemical Society, Burlington House, Piccadilly, W.
Do.	*Geological Society, Burlington House, Piccadilly, W.
Do.	*Linnean Society, Burlington House, Piccadilly, W.

EDINBURGH, . . Royal Medical Society.
Do. . . *Royal Scottish Society of Arts.
Do. . . *Royal Scottish Geographical Society.
Do. . . *Botanical Society.
Do. . . *Highland and Agricultural Society.
Do. . . *Geological Society.
GLASGOW, . . *Philosophical Society.
Do. . . *Natural History Society.
Do. . . *Geological Society.
Do. . . University Library.
PERTH, . . Perthshire Society of Natural History.
ST ANDREWS, . University Library.

IRELAND.

BELFAST, . . Natural History and Philosophical Society.
DUBLIN, . . . *Royal Irish Academy.
Do. . . . *Royal Dublin Society.
Do. . . . *Royal Geological Society of Ireland.

HOLLAND.

AMSTERDAM, . . *De Koninklijke Akademie van Wetenschappen.
LEYDEN, . . *Museum van Naturlijke Histoire.
UTRECHT, . . Provinciaal Genootschap an Kunsten en Wetenschappen.

SWITZERLAND.

BASLE, . . . *Die Naturforschende Gesellschaft.
BERN, . . . *Allgemeine Schweizerische Gesellschaft für die gesammten Naturwissenschaften.
Do. . . . *Die Naturforschende Gesellschaft.
GENEVA, . . *Société de Physique et d'Histoire Naturelle.
NEUFCHATEL, . *Société des Sciences Naturelles.
ZÜRICH, . . . *Die Naturforschende Gesellschaft.

GERMANY.

BERLIN, . . . *Königliche Akademie der Wissenschaften.
Do. . . . *Deutsche Geologische Gesellschaft.
Do. . . . *Gesellschaft Naturforschender Freunde.
BONN, . . . *Naturhistorischer Verein der preussischen Rheinlande, Westfalens, und des Reg.-Bezirks Osnabrück.
BREMEN, . . *Verein für Naturwissenschaft.
BRESLAU, . . *Schlesische Gesellschaft für Vaterländische Cultur.
BRUNSWICK, . . *Naturwissenschaftlicher Verein.
DRESDEN, . . Königliche Sammlungen für Kunst und Wissenschaft.
Do. . . . *Der Verein für Erdkunde.
ELBERFELD, . . *Naturwissenschaftlicher Verein.
ERLANGEN, . . University Library.
FRANKFORT-ON-MAIN, *Senckenbergische Naturforschende Gesellschaft.
Do. . *Deutsche Malakozoologische Gesellschaft, Dr Kobelt, Schwanheim.
FREIBURG, i. B., . Die Naturforschende Gesellschaft.
GÖTTINGEN, . . *Königliche Gesellschaft der Wissenschaften.
HALLE, . . . *Kaiserliche Akademie der Naturforscher.

JENA, . . . *Medicinisch-naturwissenschaftliche Gesellschaft.
LEIPZIG, . . . *Königliche Sächsische Gesellschaft der Wissenschaften.
Do. . . . Naturforschende Gesellschaft.
Do. . . . Editor of the *Zoologischer Anzeiger*.
MUNICH, . . *Königliche Baierische Akademie der Wissenschaften.
STUTTGART, . . *Verein für Vaterländische Cultur in Württemberg.
WÜRZBURG, . . *Physikalisch-medicinische Gesellschaft.

AUSTRIA.

AGRAM, . . . *Societas Croatica Historico-naturalis.
HERMANNSTADT, . *Siebenbürgischer Verein für Naturwissenschaft.
PRAGUE, . . Königliche-böhmische Gesellschaft der Wissenschaften.
TRIESTE, . . Società Adriatica di Scienze Naturali.
VIENNA, . . *K.k. zoologisch-botanische Gesellschaft.
Do. . . *K.k. Naturhistorisches Hof-Museum.

ITALY.

BOLOGNA, . . *Accademia delle Scienze dell' Istituto.
MILAN, . . . *Reale Istituto Lombardo di Scienze, Lettere ed Arti.
Do. . . . Società Italiana di Scienze Naturali.
MODENA, . . Società dei Naturalisti.
NAPLES, . . Editor of the *Zoologischer Jahresbericht*, Zoological Station.
PADUA, . . . *Società Veneto-Trentina di Scienze Naturali residente in Padova.
ROME, . . . *Reale Accademia dei Lincei.
TRIESTE, . . Società Adriatica di Scienze Naturali.
TURIN, . . . *Reale Accademia delle Scienze.

SPAIN.

MADRID, . . *Real Academia de Ciencias exactas, fisicas e naturales.
Do. . . . Sociedad española de Historia natural.

SCANDINAVIA.

BERGEN, . .	*The Museum.
CHRISTIANIA, .	*Den Naturhistoriske Forening.
Do. . .	Universitets Bibliothek.
COPENHAGEN, . .	*Kongelige Danske Videnskabernes Selskab.
Do. . .	*Naturhistoriske Forening.
STOCKHOLM, . .	*Kongliga Svenska Vetenskaps-Akademie.
UPSALA, . . .	*Kongliga Vetenskaps-Societeten.
Do. . . .	*Observatoire Météorologique.

RUSSIA.

DORPAT, . . .	*Naturforscher Gesellschaft.
KIEV, . . .	*Natural History Society.
MOSCOW, . .	*Société Impériale des Naturalistes.
ST PETERSBURG, .	*Académie Impériale des Sciences.
Do. .	*Imperial Botanic Garden.

AMERICA.

UNITED STATES.

ALBANY, N.Y., .	*New York State Library.
BALTIMORE, . .	*Johns-Hopkins University Library.
BOSTON, . . .	*American Academy of Arts and Sciences.
Do. . . .	*Society of Natural History.
BROOKVILLE, IND.,	*Brookville Society of Natural History.
CAMBRIDGE, MASS.,	*Harvard University Library.
Do. .	*Museum of Comparative Zoology.
CHICAGO, . .	Academy of Sciences.
CINCINNATI, . .	*Society of Natural History.
NEWHAVEN, CONN.,	*Connecticut Academy of Arts and Sciences.
Do. .	Yale College Library.
NEW YORK, . .	*New York Academy of Sciences.
OHIO, . . .	*Mechanics Institute.
PHILADELPHIA, .	*Academy of Natural Sciences.
Do. . .	*Wagner Free Institute.
SAN FRANCISCO, .	*California Academy of Sciences.
ST LOUIS, . .	*Academy of Sciences.
WASHINGTON, .	*Smithsonian Institute.
Do. . .	Philosophical Society.
Do. . .	*United States National Museum.
Do. . .	*United States Geological Survey.
Do. . .	United States Commissioner of Fish and Fisheries.

MEXICO.

MEXICO, . .	*Ministerio de Fomento de la Republica, Osservatorio Meteorologico.
Do. . .	*Sociedad Cientifica, "Antonio Alzate," Osservatorio Meteorologico Central.

CANADA.

HAMILTON, . .	*The Hamilton Association.
KINGSTON, . .	*Queen's University.

MANITOBA, . .	*Historical and Scientific Society, Winnipeg.
MONTREAL, . .	*The Natural History Society.
OTTAWA, . .	*Canadian Geological Survey.
Do. . .	*Royal Society of Canada.
TORONTO, . .	*The Canadian Institute.

NOVA SCOTIA.

HALIFAX, . .	*Nova Scotia Institute of Natural Science.

BRAZIL.

RIO DE JANEIRO, .	Museu Nacional.

AFRICA.

CAPE TOWN, . .	South African Philosophical Society.

ASIA.

BATAVIA, . .	*Koninklijke Natuurkundige Vereeniging in Nederlandsch-Indie.
CALCUTTA, . .	Royal Asiatic Society of Bengal.
SHANGHAI, . .	*China Branch of the Asiatic Society.
TOKIO, JAPAN, .	*Imperial University of Japan.

AUSTRALASIA.

ADELAIDE, . .	*Royal Society of South Australia.
MELBOURNE, . .	*Royal Society of Victoria.
SYDNEY, . . .	*Royal Society of New South Wales.
Do. . . .	*The Australian Museum.
Do. . . .	*Linnean Society of New South Wales.
WELLINGTON, . .	*New Zealand Institute.

LIST OF FELLOWS,

As at 31st December 1888.

*Those marked * are Life Members.*

Date of Election.

1856. *Anderson, John, M.D., LL.D., F.R.SS.L. & E., F.S.A., F.L.S., F.Z.S., 71 Harrington Gardens, London, S.W.
1880. Anderson, J. M., S.S.C., Strathearn Lodge, 1 Strathearn Place.
1872. Anderson, James, 105 Mayfield Road.
1881. Andrew, George, S.S.C., Woodville, Colinton.
1888. Ap Iwan, Mihangel, M.B., C.M., Independent College, Bala, N. Wales.
1884. Armitage, J. A., B.A., 15 Waterloo Road, S., Wolverhampton.
1884. Baildon, Henry B., B.A.Cantab., Duncliffe, Murrayfield.
1884. Baily, Edwin, M.B., C.M., Victoria Crescent, Oban.
1886. Ballantyne, John W., M.B., C.M., 50 Queen Street.
1885. Barbour, A. H. F., M.A., B.Sc., M.D., 24 Melville Street.
1885. Barrett, W. H., M.B., C.M., 13 Rillbank Terrace.
1880. Barron, H. J., M.D., The Hawthorns, Church End, Finchley, London, N.
1886. Barry, J. Houston, 16 Mayfield Gardens.
1884. Beaumont, Alfred, 30 Ladywell Park, Lewisham, Kent.
1880. *Beddard, F. E., M.A.Oxon., Zoological Gardens, London.
1875. Bennie, J., Geological Survey Office.
1881. *Berry, W., of Tayfield, Newport, Fife.
1880. Bird, G., 24 Queen Street.
1883. Black, Alexander, M.B., C.M., M.R.C.P.E., 8 St Vincent Street.
1883. Bowie, A. F., 16 Duncan Street, Newington.
1885. Brook, George, F.R.S.E., F.L.S., The University.
1876. Brown, J. A. Harvie, F.R.S.E., F.Z.S., Dunipace House, Larbert.
1885. Brown, J. Macdonald, M.B., F.R.C.S., Apsley Lodge, Grange.
1860. Brown, Robert, M.A., Ph.D., Fersley, Rydal Road, Streatham, London, S.W.
1886. Bruce, Alexander, M.A., M.B., F.R.C.P.E., F.R.S.E., 13 Alva Street.
1876. *Bruce, W. P., Kinleith Mills, Currie.
1883. Bryson, W. A., 20 Lomond Road, Trinity.
1878. Buchanan, J. Hamilton, C.A., 4 Doune Terrace.
1885. Buckley, T. E., B.A., F.Z.S., Millerton, near Inverness.
1885. Burt, Robert F., 124 Stroud Green Road, Finsbury Park, London, N.
1881. Cadell, H. Moubray, B.Sc., F.R.S.E., of Grange, Bo'ness.

Date of Election.

1886. Cadell, John M., M.B., C.M., Surgeon, Bengal Army, 13 Douglas Crescent.
1887. Calderwood, W. L., Craigrowan, 7 Napier Road.
1886. Campbell, Andrew, Oil Works, Linlithgow.
1880. Campbell, W., L.D.S., 27 Tay Street, Dundee.
1876. *Carmichael, T. D. Gibson-, Melrose.
1877. *Carmichael, Sir W. H. Gibson-, Bart., Castlecraig, Dolphinton.
1858. Carruthers, W., F.R.S., British Museum, London.
1830. Carter, W. A., A.I.C.E., 5 St Andrew Square.
1881. Christie, W., Jun., Ardveich, Liberton.
1887. Clarke, E. Wearne, B.Sc., M.B., C.M., 31 Inverleith Row.
1879. Coates, H., Pitcullen House, Perth.
1853. Cobbold, Spenser, M.D., F.R.S., 74 Portadown Road, Maida Vale, London.
1881. Cook, C., W.S., 11 Great King Street.
1887. *Corke, H. C., F.R.S., 178 High Street, Southampton.
1888. Corner, John, Architect, 6 Claremont Terrace.
1883. Cowper, J., Royal Infirmary.
1885. Cox, Ernest F. De Lecq Le Gresley, L.D.S., The Cedars, Green Street, Jersey.
1881. Craig, A., Jun., 16 Blacket Place.
1874. Crawford, W. C., Lockharton Gardens, Slateford.
1850. Crole, D., 1 Royal Circus.
1884. Cumming, W. J. H., 6 Barnton Terrace.
1884. Cunningham, J. T., B.A.(Oxon.), F.R.S.E., Marine Biological Laboratory, Plymouth.
1877. *Dalgleish, J. J., 8 Athole Crescent.
1885. Dendy, Arthur, B.Sc., The University, Melbourne, Victoria.
1887. Denholm, George, 38 Great King Street.

Date of Election.

1887. Foulis, James, M.D., F.R.C.P.E., 34 Heriot Row.
1887. Fulton, T. Wemyss, M.B., C.M., 23 Royal Crescent.
1877. Galletly, A., Museum of Science and Art.
1880. Geddes, Professor Patrick, F.R.S.E., James Court, Lawnmarket.
1884. Geikie, Professor James, F.R.S., The University.
1883. Gemmill, William, M.D., Drummore, by Stranraer.
1883. Gibson, E., 1 Eglinton Crescent.
1881. Gibson, J., Ph.D., F.R.S.E., 29 Greenhill Gardens.
1880. Glover, J., S.S.C., 1 Hill Street.
1883. Gray, John, Clippens Oil Works, Johnstone.
1828. Grieve, D., F.R.S.E., Lockharton Gardens, Slateford.
1877. Grieve, S., 19 Abercorn Terrace, Portobello.
1886. Grieve, Symington, 1 Burgess Terrace.
1885. Gulland, G. Lovell, M.A., B.Sc., 6 Randolph Place.
1884. Gunn, Henry H., A.R.S.M., Marionville Hall, Restalrig.
1887. Gunn, John, F.R.S.G.S., *Challenger* Expedition Commission, 32 Queen Street.
1887. Hailes, Clement D. G., M.B., C.M., M.D., Clifton, Bristol.
1883. Hallen, J. H. B., Pebworth, Stratford-on-Avon.
1883. Hamilton, J. C., Trinity Lodge, Trinity.
1881. Hamilton, R., Trinity Lodge, Trinity.
1883. Hare, A. W., M.B., F.R.S.E., 21 Ainslie Place.
1883. Henderson, J., Valley Farm, Kingsbury, Middlesex.
1883. Henderson, Prof. J. R., M.B., C.M., F.L.S., Christian College, Madras.
1883. Hepburn, David, M.B., C.M., 16 Napier Road.
1871. Herbert, A. B., 13 Polwarth Terrace.
1879. Herdman, Prof. W. A., D.Sc., F.R.S.E., University College, Liverpool.
1884. Hinxman, Lionel W., Geological Survey Office.
1882. Hogg, A., 96 George Street.
1858. *Home, D. Milne-, of Milnegraden, F.R.S.E., 10 York Place.
1886. Horn, William, Advocate, 20 Belgrave Crescent.
1878. Horne, J., F.G.S., 41 Southside Road, Inverness.
1881. Horsley, Dr R. E., 6 Melville Street.
1886. Howden, Robert, M.B., C.M., 42 Gilmore Place.
1884. Howell, Henry H., Geological Survey Office.
1883. Hoyle, W. E., M.A.(Oxon.), F.R.S.E., Ravenstone, Duke's Avenue, Chiswick.
1881. Humphrey, R., Tower Park, York Road.
1880. Hunter, James, F.R.C.S.E., Craigmillar Villas.
1874. Hunter, John, F.C.S., Minto House, Chambers Street.
1878. *Hunter, J. R. S., LL.D., Daleville, Braidwood, Lanarkshire.
1885. Hunter, William, M.B., C.M., 8 W. Maitland Street.
1850. *Jenner, Charles, F.R.S.E., Easter Duddingston Lodge, Portobello.
1877. Joass, C. Edward, 1 Rankeillor Street.
1884. Johnston, George, 76 Thirlestane Road.
1880. Johnstone, J. A., Haddington Place.
1886. Kelso, John Edward Harry, M.B., C.M., High Street, Kincardine-on-Forth.
1881. Kemp, D. W., Ivy Lodge, Trinity.

Date of Election.

1883. Kennedy, Charles, M.B., C.M., M.D., 25 Newington Road.
1869. *Kennedy, Rev. J., M.A., B.D., 36 Gillespie Crescent.
1878. Kidston, Robert, F.G.S., Victoria Place, Stirling.
Kilpatrick, H. G., 104 South Bridge.
1869. King, J. Falconer, F.C.S., Chambers Street.
1880. Laughton, W., Horton Kirby Paper Works, South Darenth, Kent.
1884. Laurie, Malcolm, Nairne Lodge, Duddingston.
1883. Lawson, G. R., Banker, Golspie.
1887. Lee, Oswin A. J., 9 Melville Crescent.
1885. Leith, R. F. C., M.A., M.B., B.Sc., 82 Marchmont Crescent.
1879. Leslie, Dr G., Falkirk.
1884. Lindsay, Robert, Curator, Royal Botanic Garden.
1886. Lisle, George, C.A., F.F.A., 5 N. St David Street, *Honorary Treasurer.*
1861. Logan, A., Register House.
1881. Lumsden, J., of Arden, Alexandria, N.B.
1870. Lyon, F. W., M.D., 5 North Charlotte Street.
1855. *Macadam, Stevenson, Ph.D., Surgeons' Hall.
1885. Macadam, W. Ivison, F.R.S.E., Surgeons' Hall.
1881. Macalpine, A. N., B.Sc., Lecturer on Biology, Minto House.
1886. M'Cracken, Professor William, Royal Agricultural College, Cirencester.
1882. *M'Donald, L. M., Skaebost, Skye.
1888. M'Fadyean, Professor, Dick Veterinary College.
1885. Macgregor, John, L.R.C.P., Rashcliffe, Huddersfield.
1878. Mackay, John Sutherland, M.A., M.D., Senior Surgeon, Rio Tinto Company, Rio Tinto, Spain.
1885. Mackenzie, William Cossar, 2 Grove Terrace.
1878. Maclauchlan, J., Albert Institute, Dundee.
1883. M'Laren, J., 25 Bread Street.
1881. Maclaren, James, L.R.C.S.E., Stirling District Asylum, Larbert.

Date of Election.

1874. Murray, D. R., M.B., C.M., 41 Albany Street, Leith.
1877. Murray, John, Ph.D., LL.D., V.P.R.S.E., *Challenger* Expedition Commission, 32 Queen Street.
1884. Murray, R. Milne, M.A., M.B., 10 Hope Street.
1880. Nicholson, Professor H. A., D.Sc., Aberdeen.
1887. Norman, Rev. Canon, M.A., D.C.L., Burnmoor Rectory, Fence Houses.
1884. Oliphant, J. C., M.A., 50 Palmerston Place.
1887. Oliver, John S., 12 Greenhill Park.
1886. Panton, George A., F.R.S.E., 95 Colmore Row, Birmingham.
1858. *Paterson, R., M.D., 32 Charlotte Street, Leith.
1870. Peach, B. N., F.R.S.E., F.G.S., Geological Survey Office.
1880. Pearcey, F., *Challenger* Expedition Commission, 32 Queen Street.
1881. Pottage, J. C., 117 Princes Street.
1883. Pullar, Alfred, M.D., Leonard Bank, Beulah Hill, Upper Norwood, London, S.E.
1879. Pullar, R. D., Tayside, Perth.
1885. Raeburn, Harold, 49 Manor Place.
1881. *Ramsay, Captain Wardlaw, Bonnyrigg.
1884. Rattray, John, M.A., B.Sc., F.R.S.E., British Museum (Nat. Hist.), South Kensington, London.
1882. Rawson, H. E., F.Z.S., Fallbarrow, Bowness, Windermere.
1868. *Reid, Rev. J. Brown, Airdrie.
1881. Richardson, T., 18 Carlton Street.
1886. Roberton, Ernest, M.B., C.M., M.R.C.S., Royal Infirmary.
1861. *Robertson, T., Messrs J. Nisbet & Co., 21 Berners Street, London, W.
1883. Robertson, W. W., H.M. Office of Works, Wardie Bank.
1882. Rogers, Rev. C., D.D., LL.D., 6 Barnton Terrace, Blackhall.
1880. Rowland, Professor L. L., M.A., M.D., University, Salem, Oregon, United States.
1887. Russell, William, M.D., F.R.C.P.E., 46 Albany Street.
1884. Scott, W. Sawers, M.B., Norton Villa, Fallowfield, Manchester.
1886. Service, Robert, Laurieknowe, Maxwelltown, Dumfries.
1886. Shand, Alexander, Viewfield Place, Dunfermline.
1883. Sherriff, George, Carronvale, Larbert.
1882. Simpson, J., Anatomical Museum, The University.
1869. *Skirving, R. Scot-, 29 Drummond Place.
1877. Smith, J. A. J., F.R.C.S.E., Kimberley, South Africa.
1886. Somerville, William, of Cormiston, c/o Royal Bank of Scotland, Forrest Road.
1880. Sprague, T. B., M.A., F.R.S.E., 29 Buckingham Terrace.
1880. Stark, A. C., M.B., C.M., Whiteparish, near Salisbury.
1882. Stewart, R., S.S.C., 21 Warriston Crescent.
1882. Stirling, J., of Garden, Stirlingshire.
1861. *Struthers, J., M.D., 22 Charlotte Street, Leith.
1886. Stuart, J. Moody, Actuary, 43 Queen Street.
1888. Stump, E. C., 28 Parkfield Street, Moss Lane East, Manchester.
1887. Sturman, E Albert, M.A., LL.D., 160 Holland Road, Kensington, London, W.
1878. Surenne, D. J., Actuary, 6 Warriston Crescent.

Date of Election.

1882. Swinburne, J., Eilan Shona, Salen, by Ardgour.
1879. Symington, J., M.D., F.R.S.E., 2 Greenhill Park.
1881. Tanner, T. Slingsby, 13 Cambridge Street, Hyde Park, London, W.
1851. Taylor, A., 11 Lutton Place.
1878. Thomson, Alex., 9 South St Andrew Street.
1887. Thomson, J. Arthur, F.R.S.E., 10 Kilmaurs Road.
1876. *Thomson, John, 49 Great Ormond Street, London, W.C.
1878. Thomson, M., 7 Carlton Terrace.
1874. *Thomson, R., LL.B., 6 Shandwick Place.
1885. Tomlinson, Henry T., M.B., C.M., Nuneaton, Warwickshire.
1859. Traquair, R. H., M.D., F.R.S., Museum of Science and Art.
1885. Turnbull, Percy M., Oakdale, Leytonstone, Essex.
1858. *Turner, Professor Sir William, LL.D., F.R.S., 6 Eton Terrace.
1885. Turner, William A., 6 Eton Terrace.
1874. Walcot, J., 50 Northumberland Street.
1882. Wallace, Professor R., F.R.S.E., The University.
1887. Wallace, Samuel W., The University.
1878. Watson, G. W., 3 Walker Street.
1884. Watson, William, M.D., Lockharton, Slateford, Midlothian.
1884. Webster, A. D., M.D., 20 Newington Road.
1887. Webster, Hugh A., M.A., F.R.S.G.S., F.R.S.E., Librarian, The University.
1884. White, J. Martin, of Balruddery, Dundee.
1878. White, T., S.S.C., 114 George Street.
1886. Williams, P. Caradoc, 58 Madeira Street.
1885. Williams, W. Owen, M.R.C.V.S., New Veterinary College, Gayfield Square.
1885. Wilson, Alfred C., F.C.S., Exchange Buildings, Stockton-on-Tees.
1882. Wilson, J. L. G., Geological Survey Office.

CORRESPONDING.

Date of Election.

Andrew, Rev. J., Newbury, Fifeshire.
1875. Coughtrey, Millen, M.D., Prof. Anat. and Physiology, University of Otago, New Zealand.
1858. Duncan, Rev. J., Denholm.
1870. Fraser, Rev. Samuel, Melbourne.
1861. Gordon, Rev. G., LL.D., Birnie, Elgin.
1871. Grieve, A. F., Brisbane, Queensland.
1852. Howden, J. C., M.D., Montrose.
1874. Joass, Rev. J. M., Golspie.
1874. Jolly, William, Inspector of Schools.
1879. Lapworth, Professor Charles, F.G.S., Birmingham.
1885. Lindström, Professor Gustav, Stockholm.
1871. Macdonald, John, S.S.C., 19 York Place, Edinburgh.
Mushet, David, Gloucester.
1885. Nathorst, Professor A. G., Surveyor-General, Geological Survey of Sweden, Stockholm.
1867. Robb, Rev. Alexander, Old Calabar.
1874. Stewart, Rev. Alexander, Ballachulish.

HONORARY.

1886. Beneden, P. J. van, Louvain.
1857. Chevrolat, Auguste, Paris.
1865. Colloredo-Mannsfeldt, Prince, Vienna.
1857. Dohrn, C. A., Stettin.
1857. Fairmaire, Léon, Paris.
1883. Geikie, Archibald, Director General of the Geological Survey (Ord. Memb. 1878), *Olim Præses.*
1857. Gerstaecker, A., Greifswald.
1857. Guenée, Achille, Chateaudun.
1857. Javet, Charles, Paris.
1857. Kraatz, G., Berlin.
1886. Lacaze-Duthiers, H. de, Paris.
1888. Lankester, Professor E. R., F.R.S., University College, London.
1869. Lütken, Chr., University Museum, Copenhagen.
1857. Lenectere, Marquis de Laferte, Tours.
1857. Marseul, L'Abbé de, Paris.
1858. Motschoulsky, Count Victor, St Petersburg.
1857. Macquerys, Emile, Rouen.
1857. Obert, M., St Petersburg.
1857. Reiche, M., Paris.
1888. Vines, Sydney H., M.A., F.R.S., Christ's College, Cambridge.

Fellows are requested to intimate change of Address to the Assistant Secretary, MR GUNN, *Royal Physical Society,* 18 GEORGE STREET, EDINBURGH.

INDEX.

Antiseptics, Method of testing efficacy of, 386.
Archæopteris hibernica, Forbes, 516.
Ardea alba, from Loch Katrine, 569.
Arvicola amphibia, Jenyns, 325.
,, *ater*, Macgil., 327.
Ascaris clavata, 567.
Ascrib Islands, Ornithological Visit to, 402.
Astacus, Sense of Touch in, 151.

Barbour, G. F., Obituary Notice of, 392.
Beddard, Frank E., 407.
Bennie, James, 82, 499.
Birds seen between England and Cape of Good Hope, 193.
Birds (Summer) of Shetland, 542.
Bittern, from Longniddry, 567.
Bothriocephalus proboscideus, 567.
Brook, George, 187, 362, 370.
Brown, Wm., Obituary Notice of, 393.

Cape of Good Hope (Voyages to), Birds seen, 193.
Cephalopoda (Recent), Catalogue of, 205.
Chondrosteus acipenseroides, 349.
Chryphiolepis striatus, from Loanhead, 565.
Columba œnas, 186.
Crossotheca fimbriata, Kidston, 511.
Crustacea, Abnormal Limbs of, 75.
Cunningham, J. T., 342.
Cyclopea in Human Subject, etc., 268.
Cyclotheca biseriata, Kidston, 515.

Delphinus delphis (Common Dolphin) in Firth of Forth, 346.
Didelphys, Structure of Graafian Follicle in, 407.
Duns, Professor J., 75, 325, 391.

Echinodermata of Firth of Clyde, 328.
Enhydrina Valakadyen, 385.
Ensilage, Chemical Composition of, 279.
Environment, Influence of, upon the Organism, 446.
Eurypterid Remains, Prevalence of, in Scottish Shales, 499.
Eurypterid (new), from Radstock, 438.
Evans, William, 183, 184, 186, 567.
Ewart, Professor J. Cossar, 47, 78.

Fernando Noronha, Visit to, 426.
Ferns (two Coal-measure), Fructification of, 510.
Fulmar, Breeding in Shetland, 562.
,, from North Berwick, 570.

Garganey, Foulden, Berwickshire, 564.
Glossy Ibis, Mindrim, Roxburghshire, 564.
Glyptoscorpius Kidstoni, 444.
Gray, Robert, Obituary Notice of, 393.
Gray, Mrs, Minute of Condolence sent to, 568.
Great Snipe, near Glasgow, 184.
Grouse (Black), Female assuming Plumage of Male, 567.
Gull (Little), from N. Berwick, 570.
Gulland, G. Lovell, 151.

Harvie-Brown, J. A., 284, 298, 301.
Hedgehog, Albino, 565.
Henderson, J. R., 65, 328.
Heron (Great White), from Loch Katrine, 569.
Herring Ova, Hatching of, in Deep Water, 47.
Homarus vulgaris, Reproduction of Lost Parts in, 370.
Hoyle, Wm. E., 202, 205, 337.
Hybrid between Common and Reeves' Pheasant, 567.
Hyperoodon rostratus, 25.
,, *latifrons*, 43.

Ibis falcinellus, Mindrim, Roxburghshire, 564.
Indian Water-Snake, Notes on, 385.
Isle of May, Faunal Position and Bird Life, 303.
Isle of May, Birds breeding on, 322.
,, Migratory Species, 566.

Jynx torquilla, 298.

Kelso, J. E. H., 385.
Kidston, Robert, 54, 82, 510, 516.

Larus minutus, from N. Berwick, 570.
Lee, Oswin A. J., 570.
Lepadogaster, Notes on, 143.
Liparis, Notes on, 143.
Lobster, Reproduction of Lost Parts in, 370.
Lumpenus lampetræformis (Walb.), from Aberdeen, 566.

Macadam, W. Ivison, 279.
Macpherson, Rev. H. A., 118.
Marten (*Martes foina*), from Inverness-shire, 565.
May (Isle of), Faunal Position and Bird Life, 303.
May (Isle of), Birds Breeding on, 322.
Motacilla alba, 186.
Motella, Larval Stages of, 568.
Muirhead, George, 564.

North Rona, Further Notes on, 284.
Numenius phæopus, 294, 551.

Obituary Notices, 392, 393.
Organic Remains, light shed on History of Strata by, 2.
Otocorys alpestris in East Lothian, 183.
Oviduct in Teleosteans, Development of, 342.

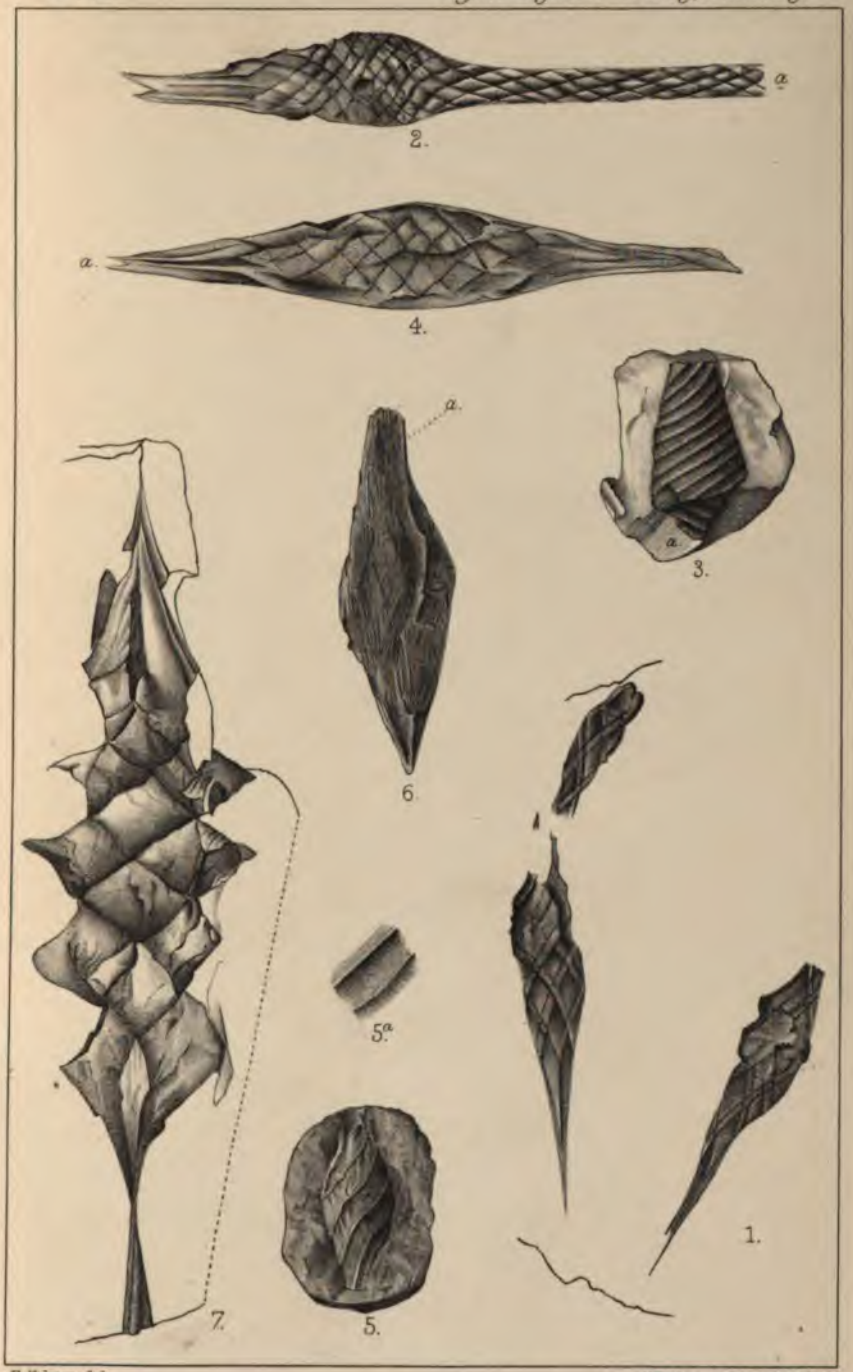
Paguridæ (British), Synopsis of, 65.
Palæoxyris, British Species of, 54.
Peach, Benjamin N., 1, 438.
Phalaropus fulicarius, 196.
Phylloscopus superciliosus, from Shetland, 298, 566.
Picus major, 298, 567.
Scolopax major, near Glasgow, 184.
Scottish Academy of Sciences, Suggested, 399.
Sea-Serpent, Bibliography of, 202.
Selachii (Carboniferous), Notes on, 412, 421.
Shells from West Coast of Africa, 337.
Shetland, Summer Birds of, 542.
Shorelark in East Lothian, 183.
Sitta cæsia, 121.
Skye, Birds of, 118.
Smith, W. Anderson, 143.
Snipe (Great), near Glasgow, 184.
Snow Bunting (young), from Sutherlandshire, 566.
Spores in Carboniferous Formation of Scotland, 82.
Stock Dove, 186.
Sucker Fishes, Notes on, 143.
Swinburne, John, 402.
Swinburne, Spearman, 193.
Sylvia nisoria, Skye, 120.
Symington, Johnson, 268.

Teal (Blue-winged), from Dumfriesshire, 569.
Teleosteans, Development of Oviduct in, 342.
Teleosteans, Relation of Yolk to Blastoderm in Ova of, 187.
Thomson, J. Arthur, 446.
Traquair, Dr R. H., 349, 412, 421, 569.
Turner, Professor Sir Wm., 25, 346.

Vole (Water), Notes on, 325.
Voyages to Cape of Good Hope, Birds seen, 193.

PLATE I.

Vol. IX. *Royal Physical Society, Edinburgh.*



R. Kidston, del. M^cFarlane & Erskine, Lith^rs Edin^r

Fig. 1. PALÆOXYRIS HELICTEROIDES, MORRIS SP. 2-3. P. CARBONARIA, SCHIMPER. 4-5. P. PRENDELII, LESQX. 6. P. JOHNSONI, KIDST. 7. P. TRISPIRALIS, KIDST.

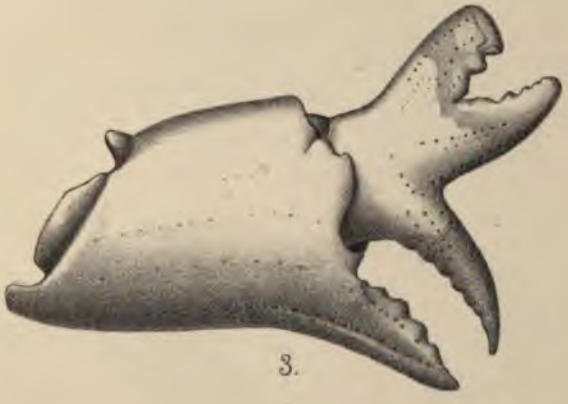
PLATE II.

Vol. IX. *Royal Physical Society, Edinburgh.*

4.

1.

2.



3.

J. Dunn

M'Farlane & Erskine, Lith.rs Edin.r

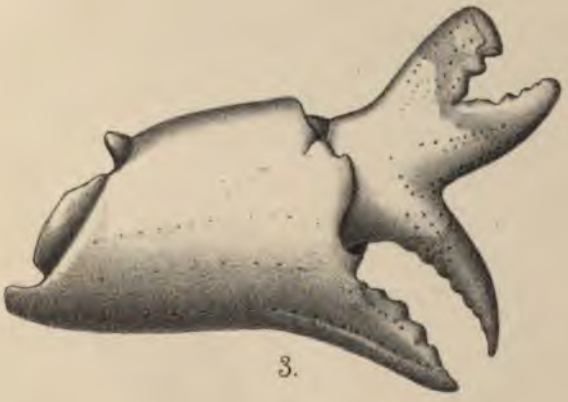
PLATE II.

Vol. IX. *Royal Physical Society, Edinburgh.*

4.

1.

2.



3.

J. Dunn. M'Farlane & Erskine, Lith. Edin.

PLATE III.

Vol. IX. *Royal Physical Society, Edinburgh.*

CARBONIFEROUS LYCOPOD MACROSPORES.

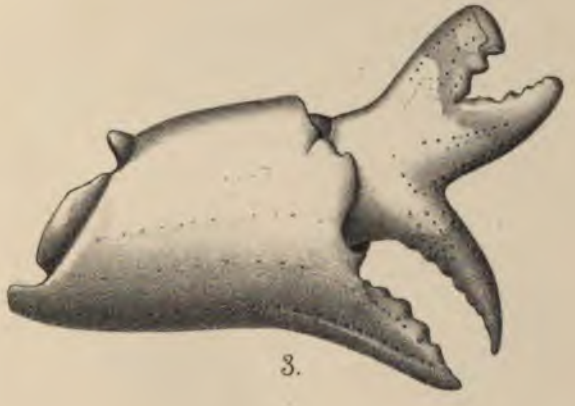
PLATE II.

Vol. IX. *Royal Physical Society, Edinburgh.*

4.

1.

2.



3.

J. Duns.

PLATE III.

Vol. IX. *Royal Physical Society, Edinburgh.*

R. Kidston, del. M'Farlane & Erskine, Lith^rs Edin^r

CARBONIFEROUS LYCOPOD MACROSPORES.

PLATE IV.

P. Kidston, del. M'Farlane & Erskine, Lith^rs Edin^r

CARBONIFEROUS LYCOPOD MACROSPORES.

PLATE III.

Vol. IX. *Royal Physical Society, Edinburgh.*

R. Kidston, del. M'Farlane & Erskine, Lith^rs Edin^r

CARBONIFEROUS LYCOPOD MACROSPORES.

PLATE IV.

R. Kidston, del.

CARBONIFEROUS LYCOPOD MACROSPORES.

PLATE V.

16 *a*.

16 *c*.

16 *b*.

16 *d*.

16 *e*.

18 *a*.

18 *c*.

17 *a*.

17 *b*.

19.

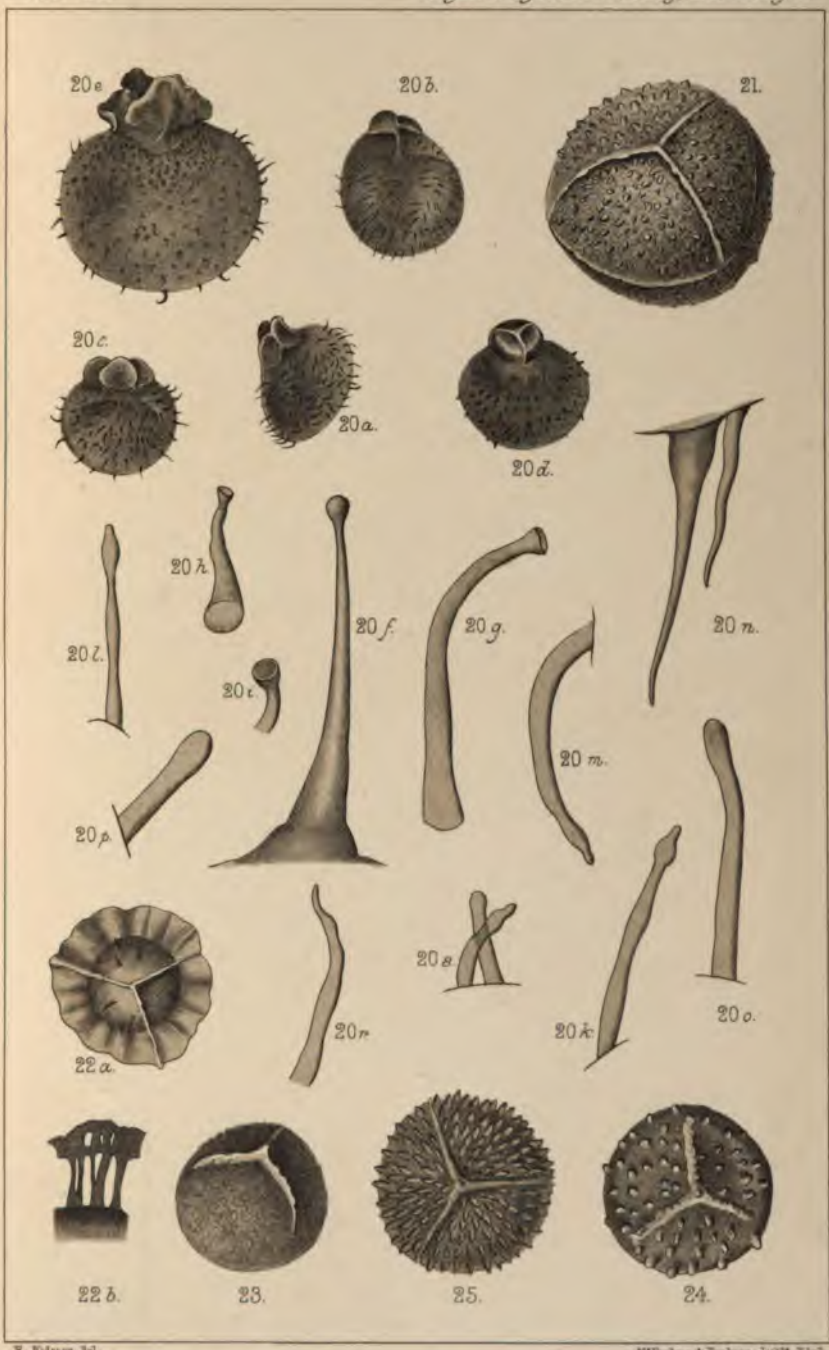
18 *b*.

R. Kidston, del. R.ᵗ Parlane & Erskine, Lith.ʳˢ Edin.ʳ

CARBONIFEROUS LYCOPOD MACROSPORES.

PLATE VI.

Vol. IX. *Royal Physical Society, Edinburgh*



R. Kidston, del. M'Farlane & Erskine, Lith^rs Edin^r

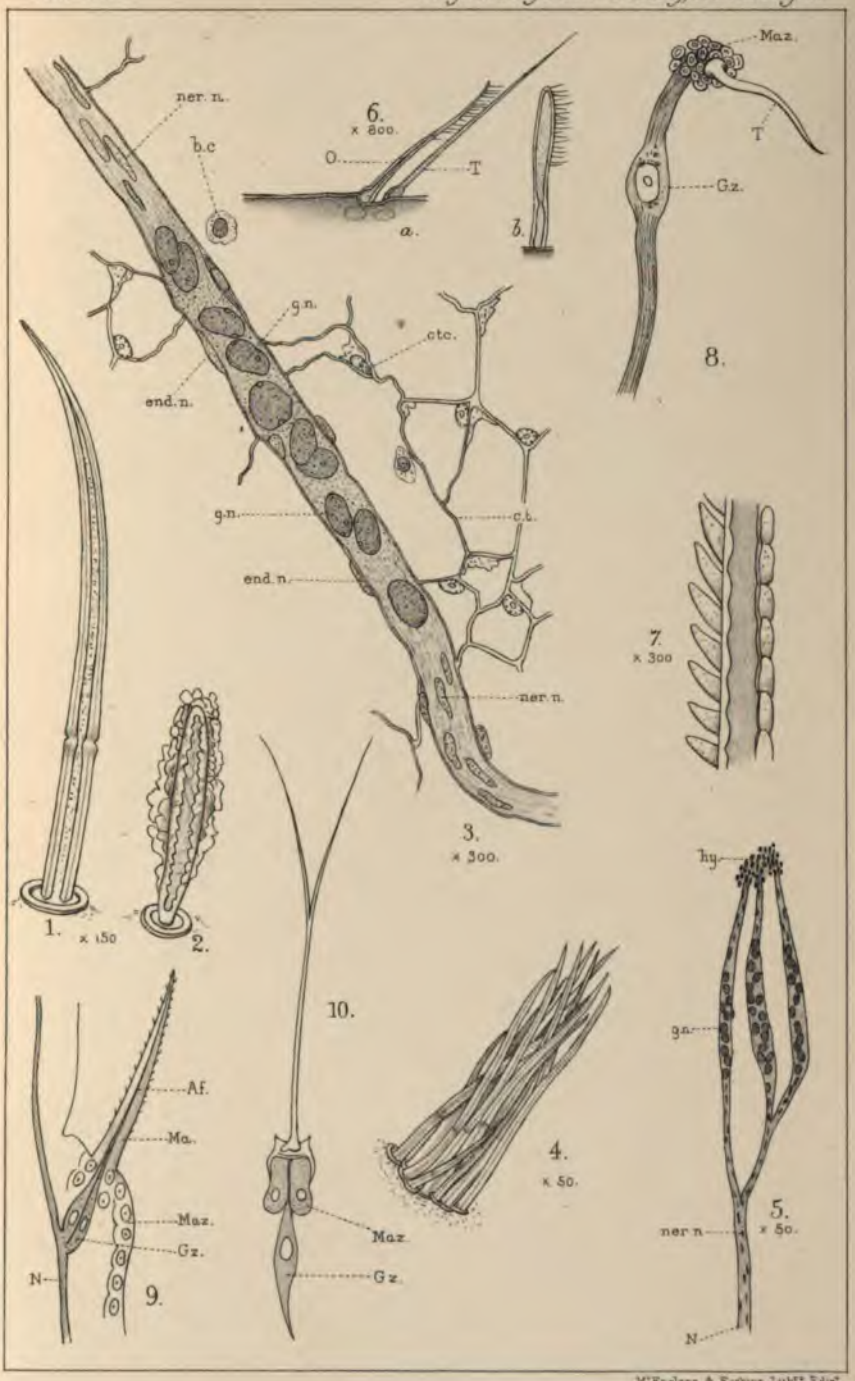
Figs. 20. CARBONIFEROUS LYCOPOD MACROSPORES.
Figs. 21–25. RECENT LYCOPOD MACROSPORES.

Vol.

W. And

PLATE VIII.

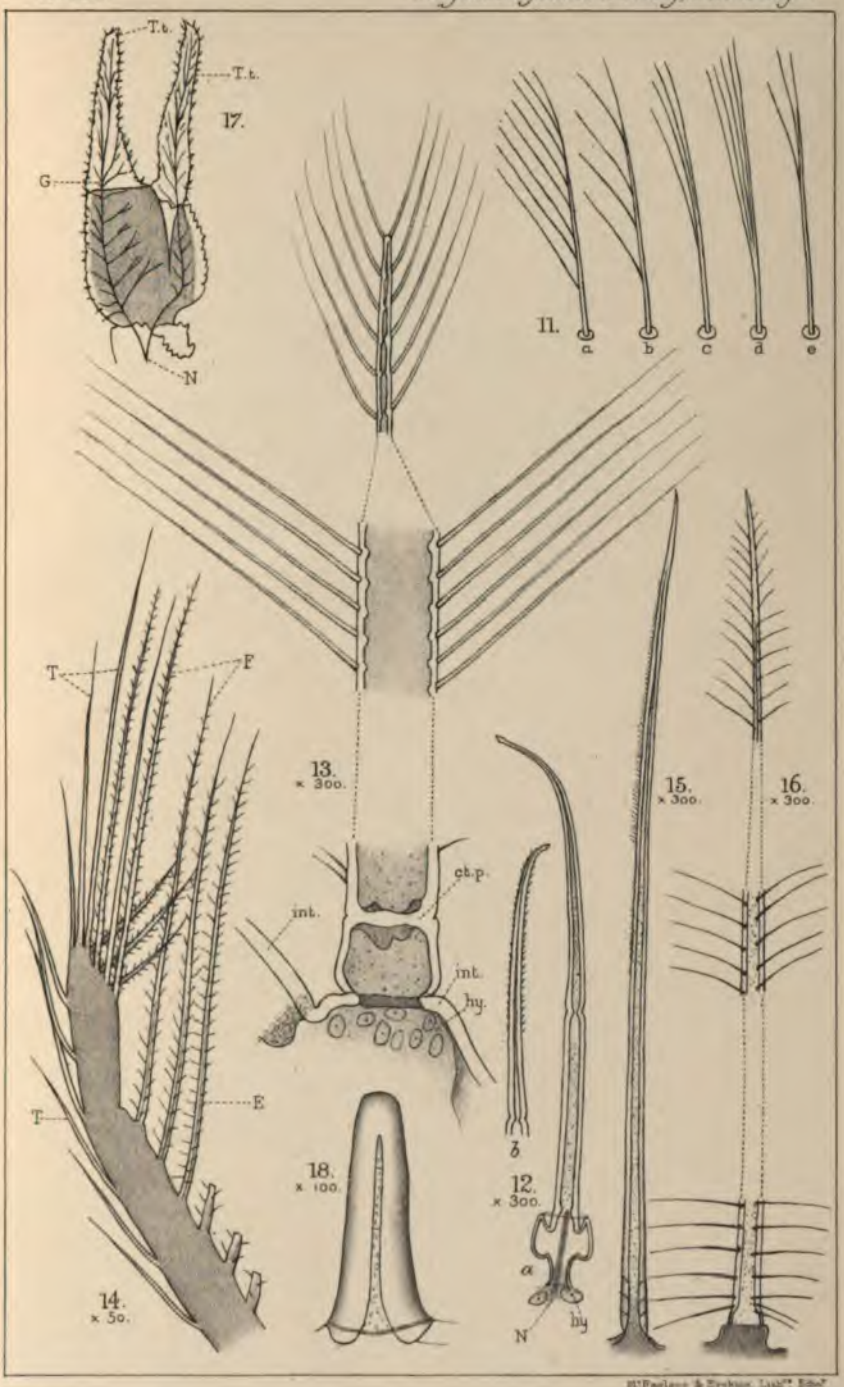
Vol. IX. *Royal Physical Society, Edinburgh.*



M'Farlane & Erskine, Lith^rs Edin^r

PLATE IX

Vol. IX. *Royal Physical Society, Edinburgh.*



M'Farlane & Erskine, Lith.rs Edin.r

PLATE X.

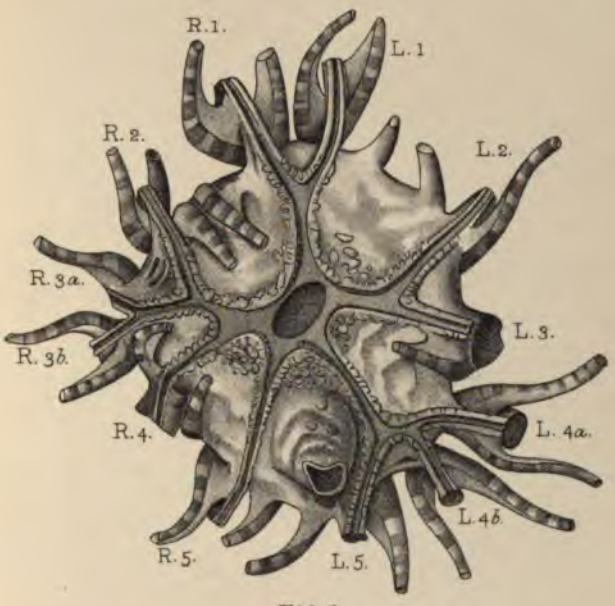


Fig. 1.

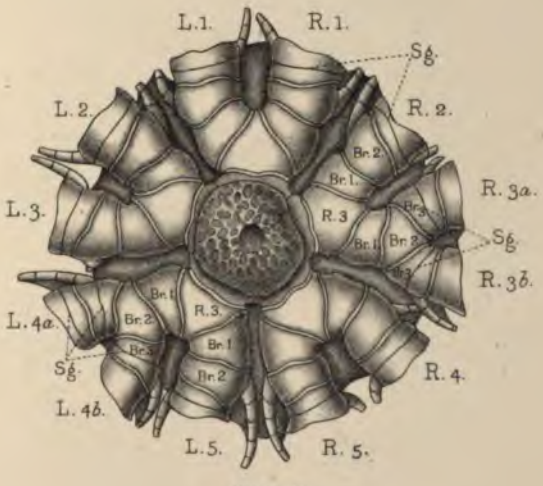


Fig. 2.

Arthur Dendy, del. M^cFarlane & Erskine, Lith^rs Edin^r

ANTEDON ROSACEA? with twelve arms. × 3.
Fig 1. Ventral Surface. Fig 2. Dorsal Surface.

SOULISGEIR

Bears W. by N. ½ N. 10 miles from S.W. point of Rona.

(Sailing Directions, 1881.)

RONA

Bears from Cape Wrath N. by W. ½ W. 39 miles, and from Butt of Lewis N.E. ½ E. the same distance.

(Sailing Directions, 1881.)

J. A. H. B. del.

M.ᶜ Farlane & Erskine, Lith.ᵖʰ Edin.ᵍʰ

SOULISGEIR

Bears W. by N. ¼ N. 10 miles from S.W. point of Rona.

(Sailing Directions, 1881.)

RONA

Bears from Cape Wrath N. by W. ½ W. 39 miles, and from Butt of Lewis N.E. ½ E. the same distance.

(Sailing Directions, 1881.)

J. A. H. B. del.

M.ᶜ Farlane & Erskine, Lith.ʳˢ Edin.ʳ

From a Photo by W. Green, Berwick

M^c^Farlane & Erskine, Lith^rs^ Edin^r^

ISLE OF MAY FROM THE WEST.

SOULISGEIR

Bears W. by N. ¾ N. 10 miles from S.W. point of Rona.
(Sailing Directions, 1881.)

RONA

Bears from Cape Wrath N. by W. ¼ W. 39 miles, and from Butt of Lewis N.E. ¼ E. the same distance.
(Sailing Directions, 1881.)

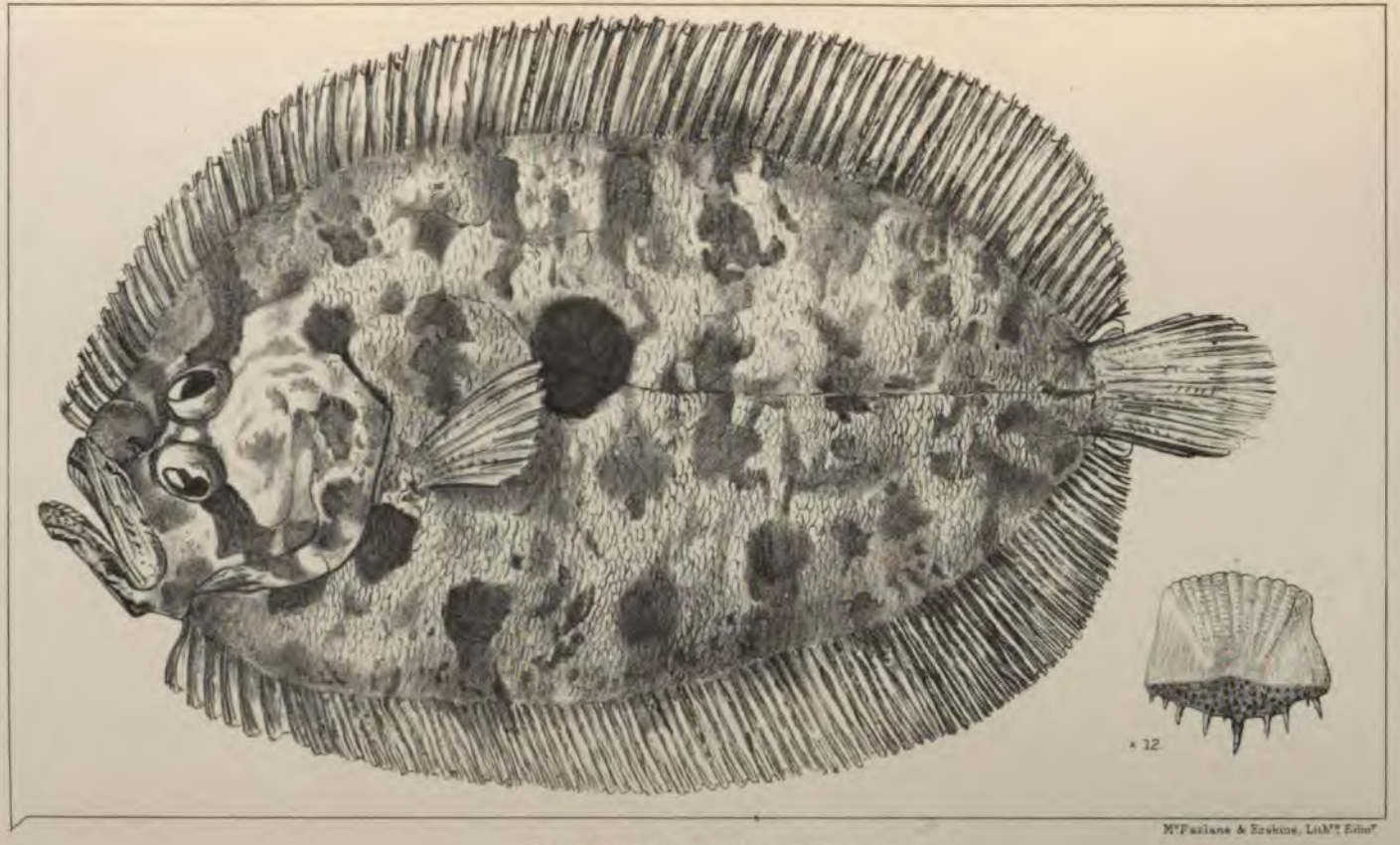
J. A. H. B. del.

M.cFarlane & Erskine, Lith.rs Edin.r

From a Photo by W. Green, Berwick. M^c^Farlane & Erskine, Lith^rs^ Edin^r^

ISLE OF MAY FROM THE WEST.

N
Magnetic North
W
E
S
North Ness
West Tarbet
East Tarbet
Tarbethole
ISLE OF MAY
EXTRA
PAROCHIAL
Lighthouse
Mill Dam
The Pillow
Chapel
Village
The Pilgrim's Haven
South Ness
Maidens Rock
Meadow Rock
SCALE
1/4 MILE
1000
2000
3000 FEET



M.Farlane & Erskine, Lith.rs Edin.r

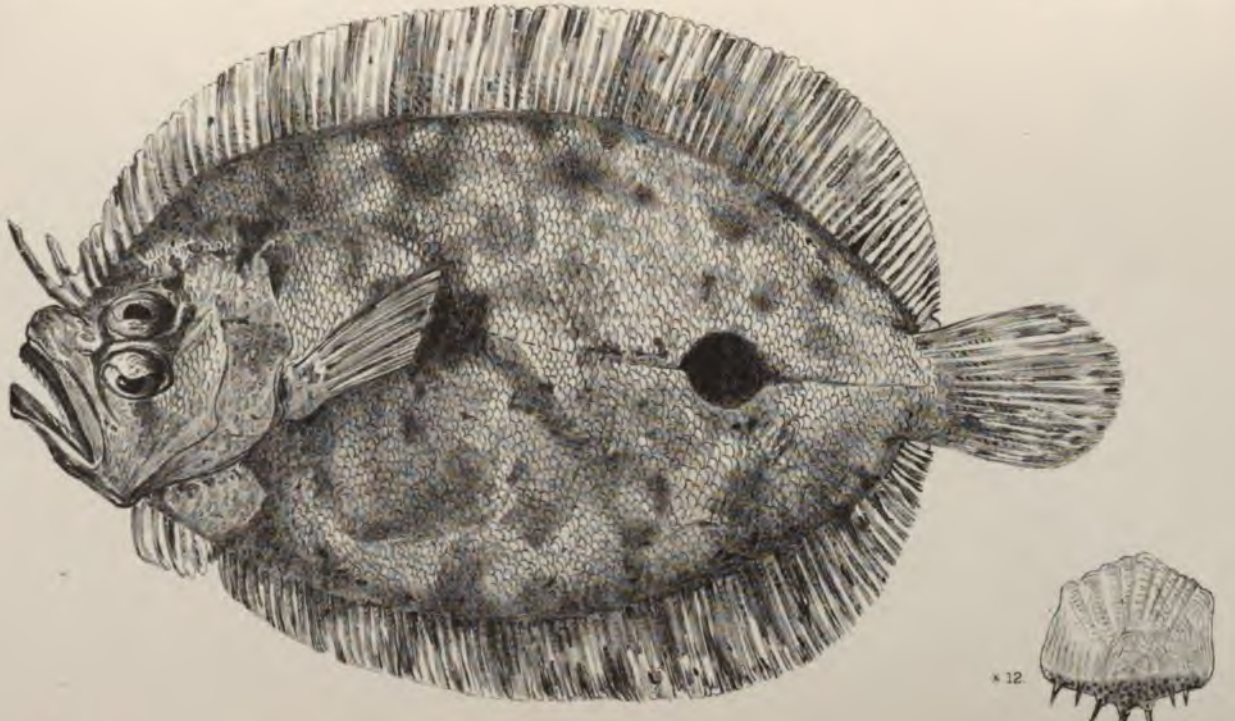
ZEUCOPTERUS PUNCTATUS Bloch

PLATE XV.

× 20.

M^cFarlane & Erskine, Lith^rs, Edin^r

ZEUGOPTERUS PAPILLOSUS. (n. s.)



× 12.

M.Farlane & Erskine, Lith.rs Edin.r

ZEUGOPTERUS UNIMACULATUS Risso.

PLATE XVII.

Vol. IX. *Royal Physical Society, Edinburgh*

Fig. 1. A.

Fig. 2, C.

Fig 3. C.

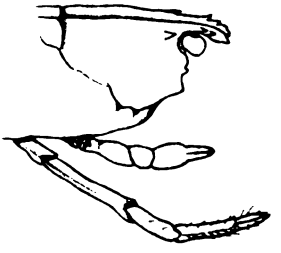


Fig. 4. C.

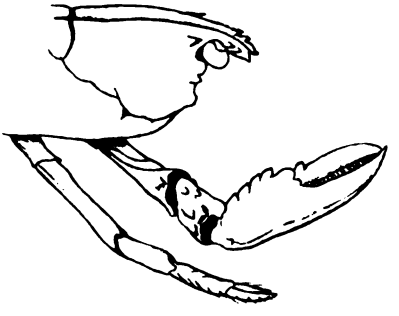


Fig. 5. C.

M.cFarlane & Erskine, Lith.rs, Edin.r

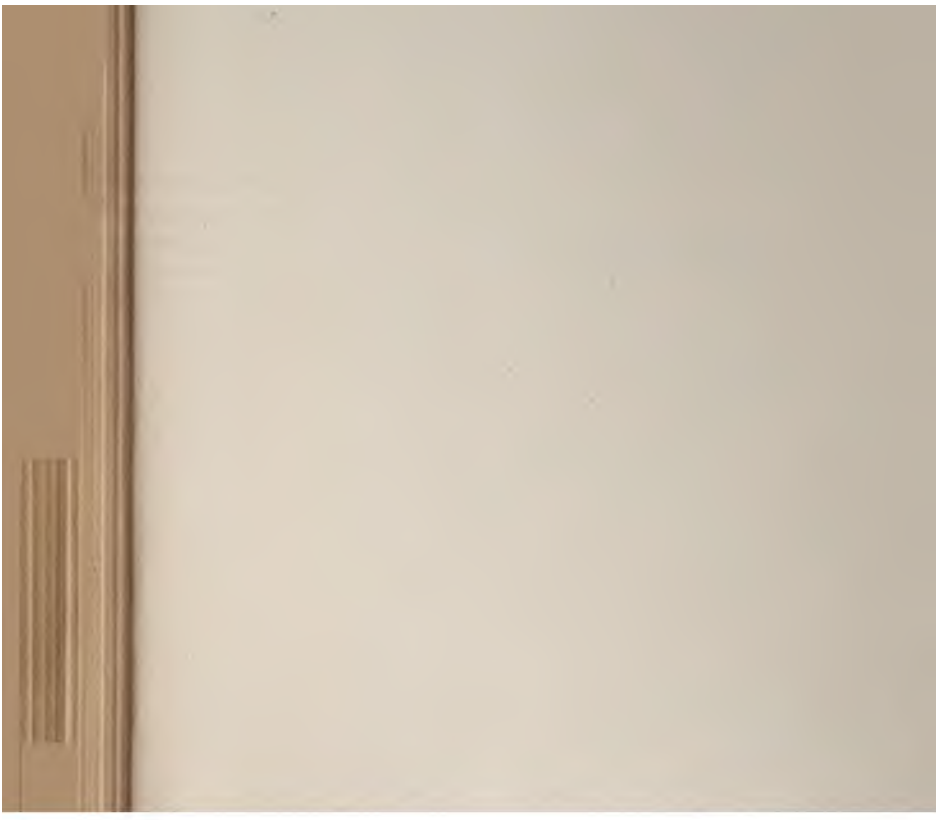


PLATE XVIII.

Fig. 1.

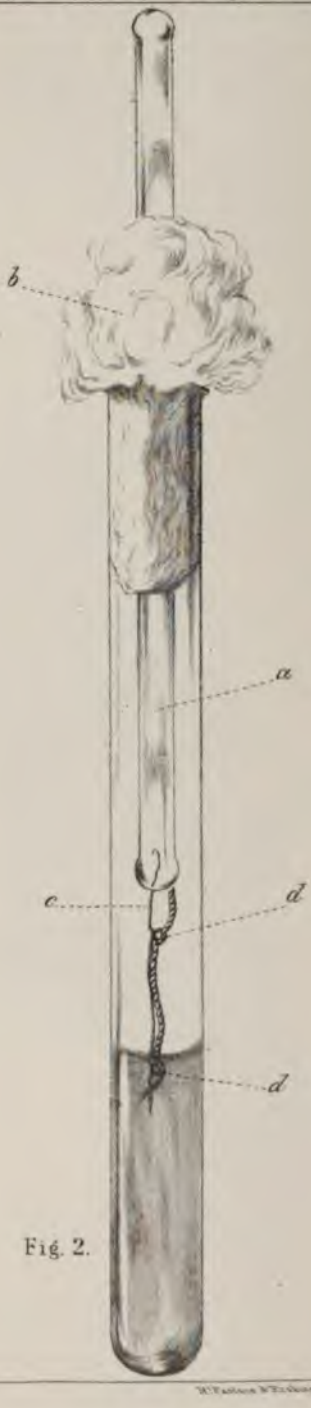
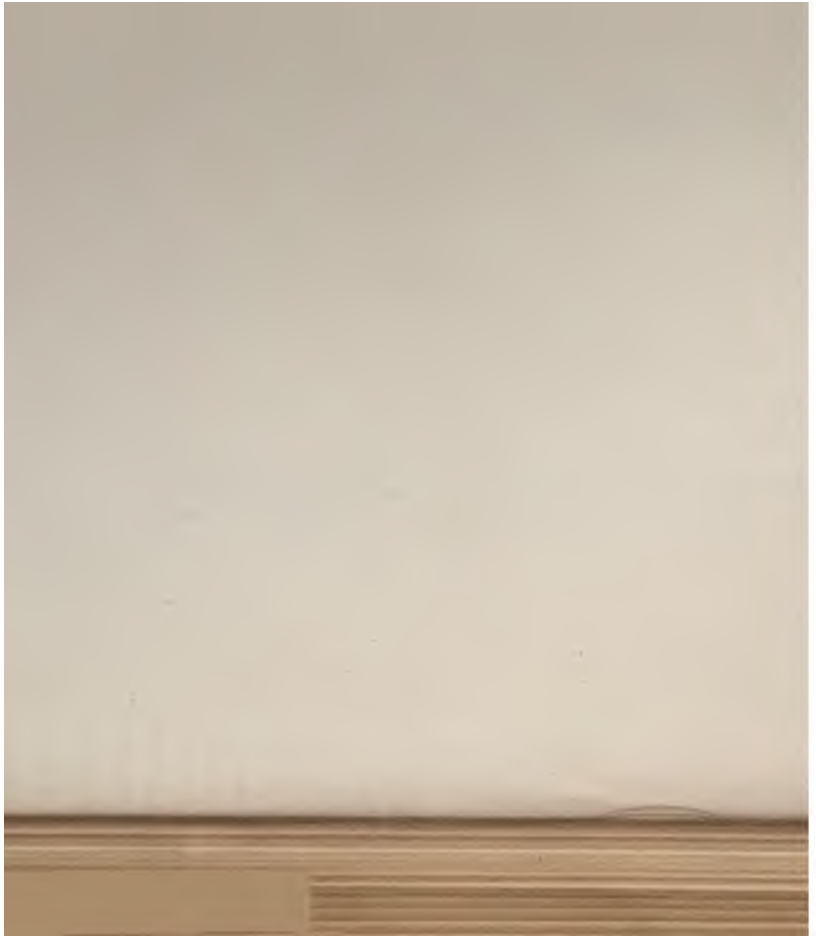
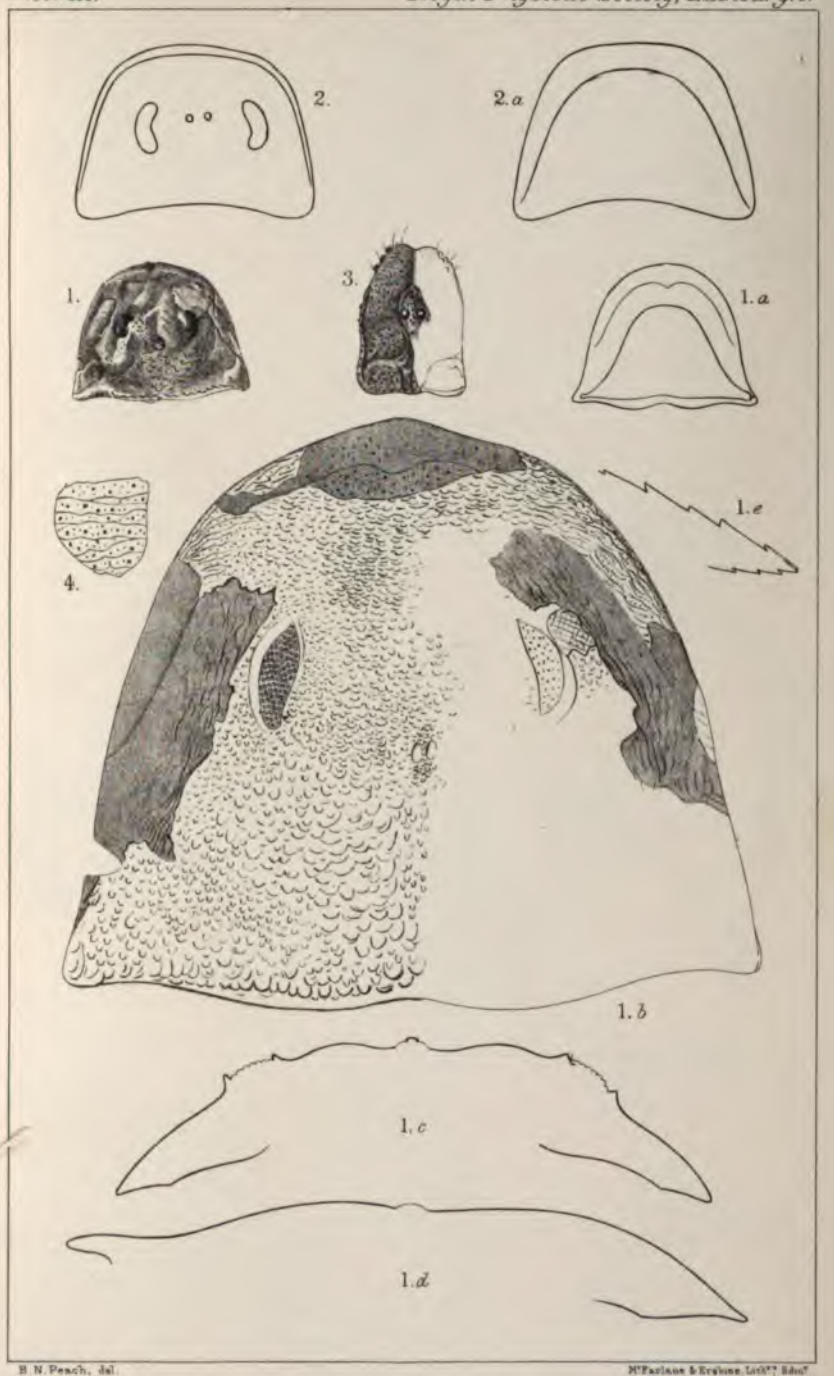


Fig. 2.



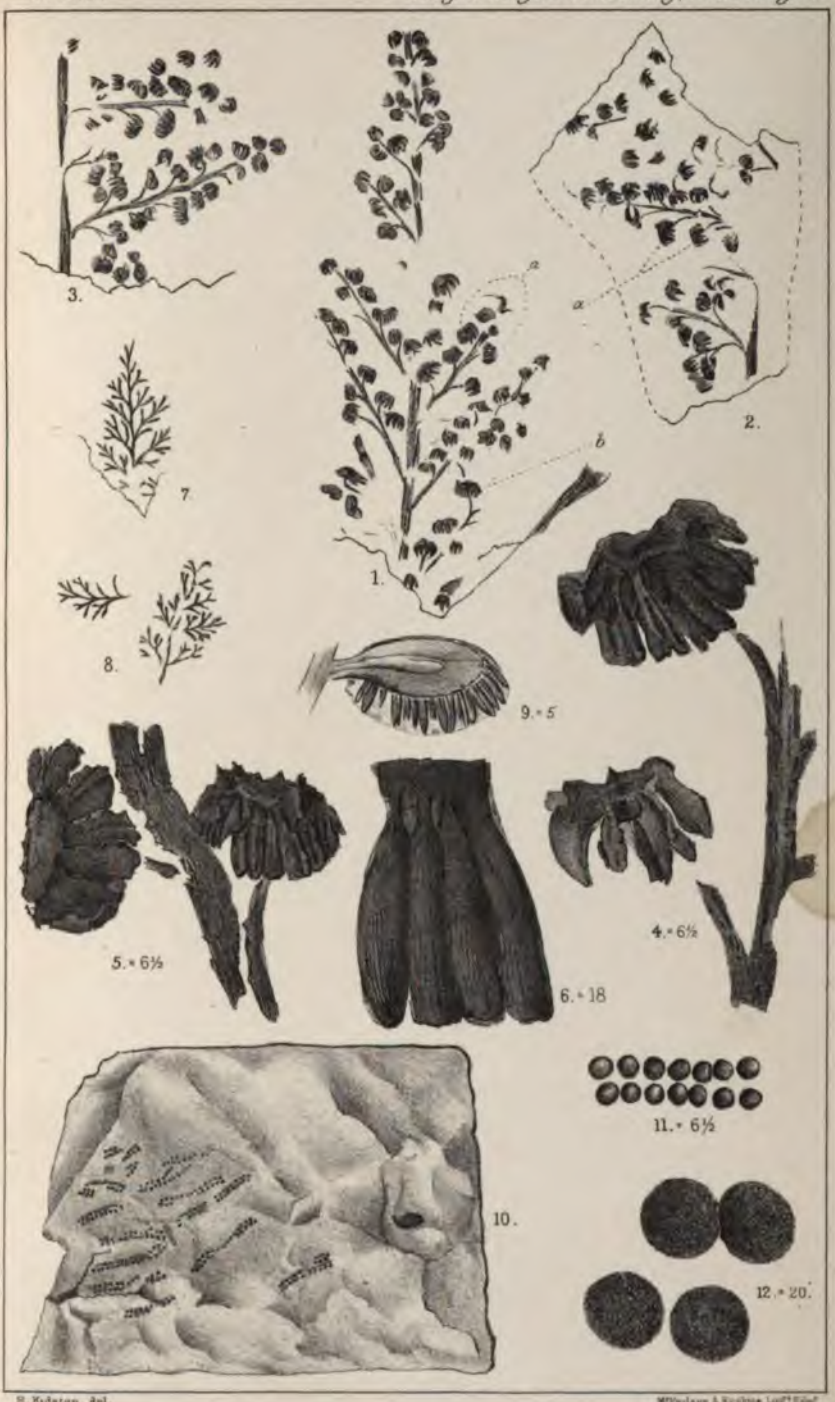
NORTH
Rat Island
Boobie Island
Platform Island or San Jose
Mt. St. Michael
Egg Island
San Antonio
Water Bay
Fort
Moro da Villa
The Peak
Sambaquichata
Twins
Portuguese Bay
East Hills
East Point
Frade or Les Clochers
Cotton Tree Bay
Look Out Hill
Leão Bay
Tangle Rock
Hole in the Wall
Cape Accellière
Sapate
Lake
Line of Cliffs
Fort Leão
Tobacco or South Point
Pedras Pretas
SOUTH
BASALT
PHONOLITE
BLOWN SAND
REEF ROCK
TUFF
WOODS
G.A.K. del.
M'Farlane & Erskine, Lith.rs Edin.r

PLATE XX.



B. N. Peach, del.

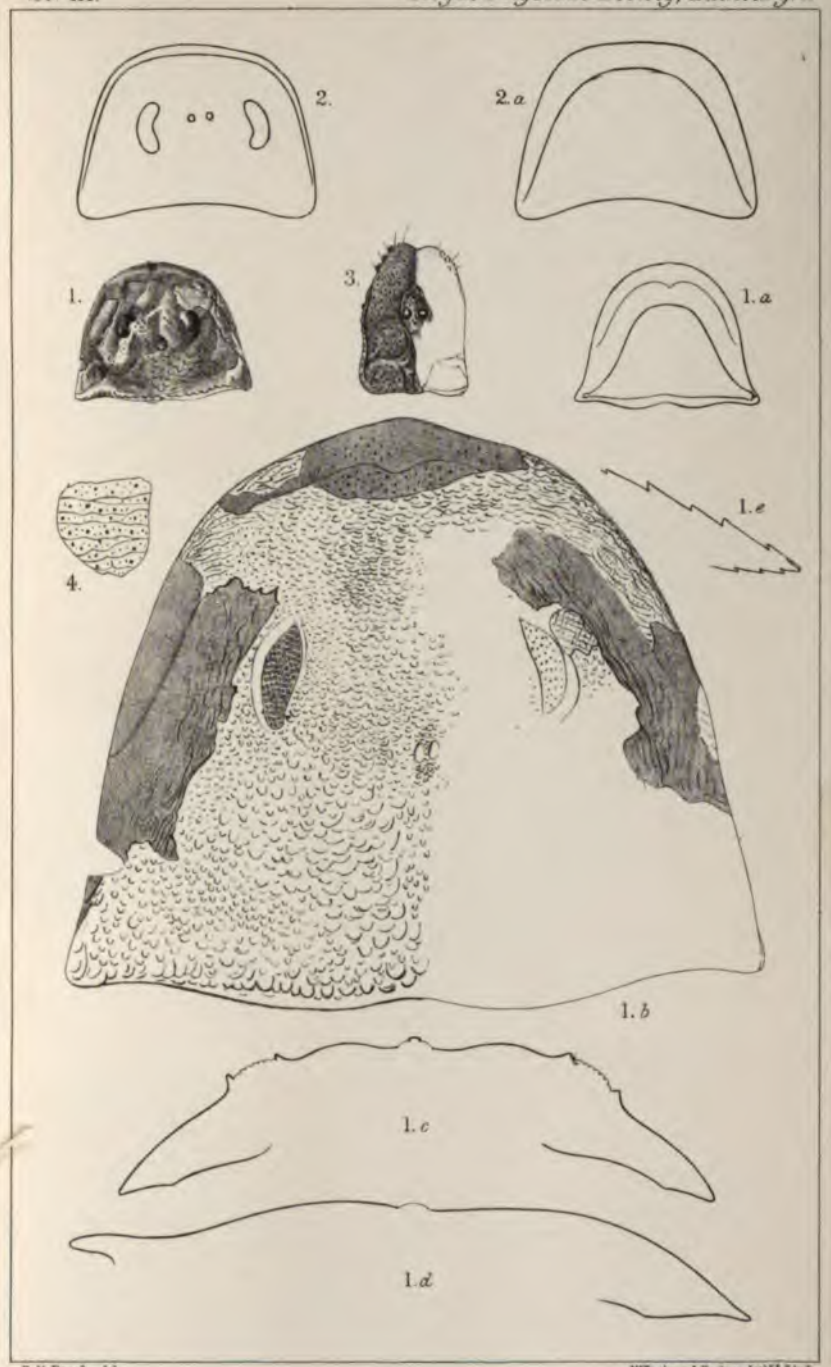
M'Farlane & Erskine, Lith.rs Edin.r



R. Kidston, del. M'Farlane & Erskine, Lith^rs Edin^r

Figs. 1-8. CROSSOTHECA FIMBRIATA, *Kidston*, n. s.
9. CROSSOTHECA CREPINI, *Zeiller*.
10-12. CYCLOTHECA BISERIATA, *Kidston*, n. s.

Plate XX.



B. N. Peach, del. M'Farlane & Erskine, Lith.rs Edin.r

PLATE XXI.

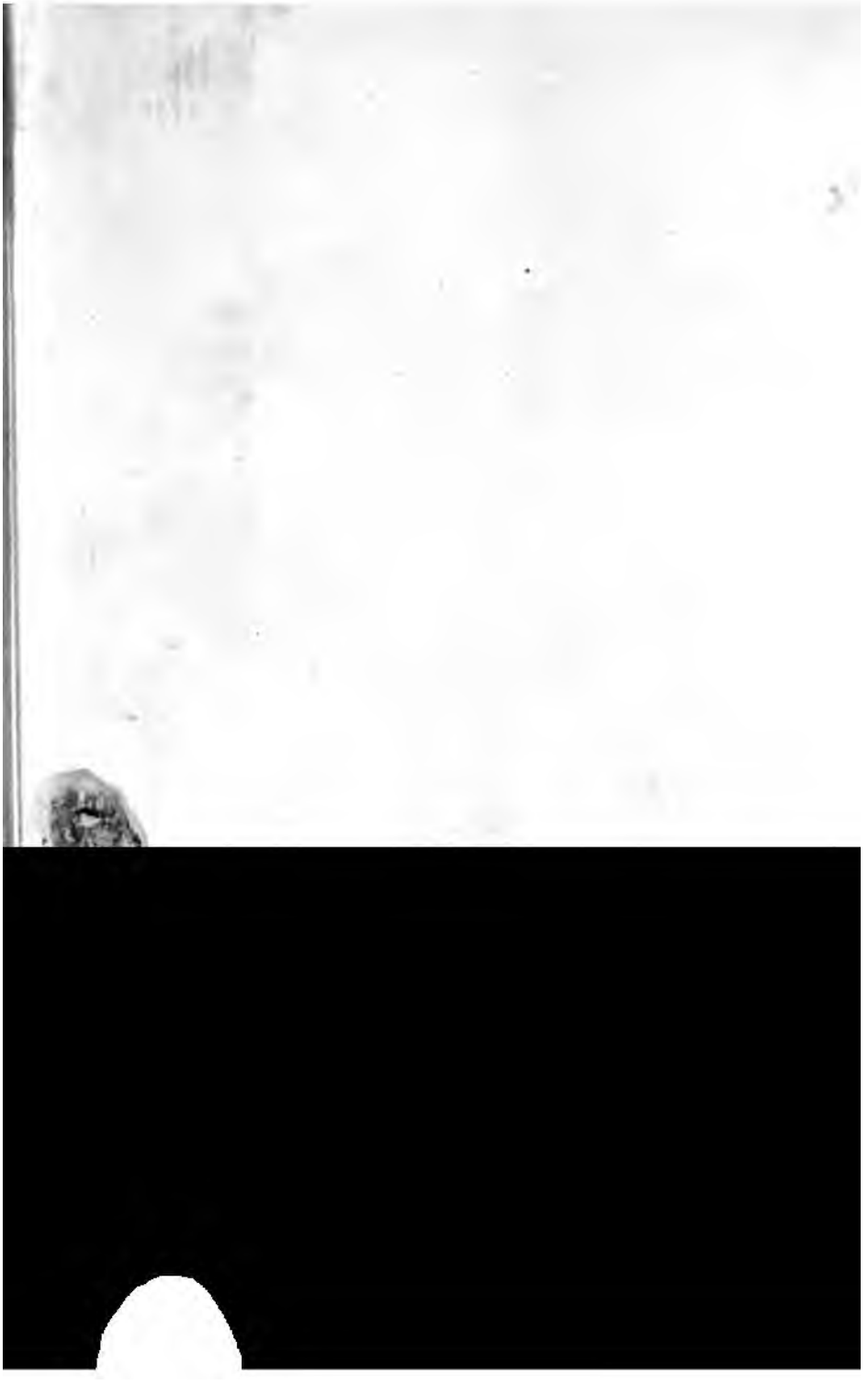
R. Kidston, del. M'Farlane & Erskine, Lith. Edin.

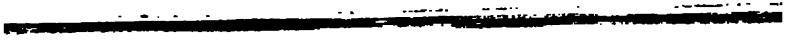
Figs. 1-8. CROSSOTHECA FIMBRIATA, *Kidston*, n. s.
9. CROSSOTHECA CREPINI, *Zeiller*.
10-12. CYCLOTHECA BISERIATA, *Kidston*, n. s.

PLATE XXI.

R. Kidston, del. M'Farlane & Erskine Lith.ph Edin.

Figs. 1-8. CROSSOTHECA FIMBRIATA, *Kidston*, n. s.
9. CROSSOTHECA CREPINI, *Zeiller*.
10-12. CYCLOTHECA BISERIATA, *Kidston*, n. s.





Stanford University Libraries
3 6105 024 630 480

STANFORD UNIVERSITY LIBRARIES
STANFORD AUXILIARY LIBRARY
STANFORD, CALIFORNIA 94305-6004
(650) 723-9201
salcirc@sulmail.stanford.edu
All books are subject to recall.
DATE DUE

DEC 26 2001
MAR 0 7 2002